Geological Survey of Ohio

GEOLOGICAL SURVEY OF OHIO

J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 18

BUILDING STONES OF OHIO

By J. A. BOWNOCKER

COLUMBUS

1915

Published by authority of the Legislature of Ohio
under the supervision of the State Geologist

Printed by the Springfield Publishing Company,
Springfield, Ohio.

Hon. James M. Cox, *Governor of Ohio:*

Dear Sir:—I transmit herewith Bulletin 18 of the Geological Survey, entitled Building Stones of Ohio. The building stone industry of our State has been prominent from the time of settlement, and yet hitherto there has been no adequate presentation of this resource. Numerous calls for information from architects and builders have been received from neighboring states as well as Ohio, and it is hoped that this bulletin will supply the desired information.

Respectfully submitted,

J. A. Bownocker,

State Geologist.

November 1, 1914.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC

The usefulness of the Survey is not limited to the preparation of formal reports on important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Requests for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the inquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2nd. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be named at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3rd. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar up to

drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

BUILDING STONES OF OHIO

TABLE OF CONTENTS

CHAPTER I

CHAPTER II

CHAPTER III

LIST OF ILLUSTRATIONS

FIGURES IN TEXT

CHAPTER I

THE GENERAL CHARACTER AND PROPERTIES OF OHIO BUILDING STONES

The building stones of Ohio all belong to the great group of rocks known as sedimentary, which are well represented by limestones and sandstones. Speaking in a somewhat general way the limestones underlie the western half of the State and the sandstones the eastern half.

The limestones vary much in their properties, some are highly fossiliferous while others are practically without fossils; some are very even bedded, others are without well-marked bedding planes, or the planes are far from parallel; some are fine grained and compact while others are open textured; some are crystalline, others non-crystalline; some are easy to work while others break with a conchoidal fracture; some have a light gray color, others a buff, and others still a dark blue. These stones, all in all, are of good quality, and well adapted to architectural purposes, but they must be selected with reference to the structure whose walls they are to form. In other words, a stone may be suited for one style of building but not for another.

The sandstones also vary much. Some are coarse grained, others fine; some compact, others porous; some in thin even beds, others massive, or the beds irregular; some are free from impurities while others contain concretionary iron or other objectionable material; some carve well, others do not. The color of the sandstones varies from dark blue, through blue-gray, gray, buff, yellow, brown to red, but the latter shade is not abundant. The sandstones of Ohio take high rank as building stone, and at least one of them is not surpassed anywhere. Since they possess such variable qualities the architect can select a variety which meets his fancy.

There are several properties of stone that have an important bearing on its value for building purposes. Chief of these are *durability, strength, color, carving, ease of quarrying, density* and *architectural effects.* These will now in turn be considered.

Durability.—This is probably the most important quality in building stone, for if it possesses all other desired characters but lacks durability, the stone cannot be regarded as of high grade. Physical and chemical forces work more or less persistently on stone, and sooner or later reduce it to fragments. Temperature changes are very important. Under the hot summer's sun, the surface of a stone may

have a temperature of 100° F. or even more, while in winter the temperature may drop to zero or lower. Changes less marked may occur within 24 hours, for while the temperature of the air at noon may be 80° F. or possibly more, it may drop near or to the frost line the following night. As is well known heat expands rocks and cold contracts them. Repeated changes of this sort, sooner or later, scale the surface of the rock and may split off large blocks. The latter in turn may be further broken by the same force and possibly reduced to fragments.

Still more effective is the freezing of water in rock. As all know, rocks contain cavities of various sizes and shapes, such as pores, and larger openings which we may call holes, also cracks, joints and bedding planes. When water freezes it expands about one-tenth in volume and with a force that is almost irresistible, being equal to the weight of a column of ice a mile high, or about 150 tons per square foot, according to Sir Archibald Geike. It is this power repeatedly applied that plays the most active part in cracking and eventually crumbling our building stone.

It is an old idea that the durability of building stone bears a close relation to its porosity. In short, the greater the porosity the less reliable the stone. According to Buckley, however, the matter is not quite so simple.[1] He claims the size of the pores or openings is very important, since it determines the freedom with which water escapes. Manifestly, if the pores are small and the rock is saturated with water, it will be retained longer in the rock than if the pores are larger, other conditions being equal. In other words, if two rocks absorb the same quantity of water, and in one the pores are much larger than in the other, the rock with the smaller pores will suffer most from freezing. This principle appears to be well illustrated in the rocks at Sugar Grove, Fairfield County, which are coarse grained and absorb a large quantity of water, and yet suffer but little from freezing.

Water freezing along bedding planes, or in more or less vertical fissures known as cracks and joints, may fracture the rock, but the evil results are much less than when the water is disseminated through the rock. If the rock is in distinct layers, as is often the case with sandstones and limestones, and the rock is laid on edge, water may enter it, and freezing, scale or shell off the surface. This method of placing rocks should never be employed. Finally it is to be kept in mind that the durability of building stone is very largely dependent on climate. This is very well shown by the obelisk which stood for many centuries in the valley of the Nile, but when placed in Central Park in New York very promptly showed signs of going to pieces, and has to be protected to keep out the water.

[1] Wisconsin Geol. and Nat. Hist. Surv. On the Building and Ornamental Stones of Wisconsin, pp. 20-25.

The chemical forces at work on building stones also tend to reduce them to fragments. Pure water is a solvent for nearly all minerals and rocks, but the rate of action is so slow that for most purposes it can be neglected. When, however, it contains carbon dioxide and forms carbonic acid the action is important. Limestones yield most readily to this acid, but all rocks give way under its action. The cement, whether it be silica, iron or calcium carbonate, is leached out, and the sandstone returns to sand from which it came. A fine illustration of this may be seen in the basement of the library building at Dayton which is constructed of the popular Lake Superior red sandstone. Quartzite, when attacked by this solvent, may return to sandstone and finally to sand. Naturally those rocks having a calcium carbonate cement respond most readily, while those having silica hold out longer against attack. Carbonic acid attacks granite also, changing its feldspar to kaolin, its hornblende and micas to more simple bodies, and of course, reduces the rock to fragments. The action on limestone is still more pronounced, as may be seen in any old cemetery where the lettering on monuments is blurred by the solvent action of the acid. The walls of the State House at Columbus, which have stood for about 60 years, show plainly this effect. The surface of the rock has responded unevenly to the attack leaving it marked with small elevations and depressions, a result probably of slight variations in the physical and chemical composition of the rock.

The action just considered has been credited to carbonic acid, but in all probability much of it belongs to acids of which sulphur is a constituent, that is, sulphurous and sulphuric acids. Especially is this true in most cities where coal with its sulphur is the chief fuel. There is another source of this objectionable element and that is in the stone itself. Limestone often contains pyrite or iron disulphide. On exposure, this speedily breaks down, forming an oxide of iron and one or more of the sulphur acids. No matter what the source of the sulphur may be, it is very effective in its attack on rocks, and particularly so on limestone.

At or near the surface of the earth, humus acids, formed from decaying organic matter, attack the rock, and their work is generally regarded as effective, though possibly much that has been credited to them really belongs to carbonic acid. Not only do they dissolve calcium carbonate and iron but they attack silica itself, and hence no rock is safe in their presence.

Other forces that aid in rock destruction are sand blasts, in which wind is the force. Naturally this is effective only in arid regions and along shore lines, and even there its work may be neglected except when geological time is involved. Walls of buildings are often covered in part with vines whose rootlets project into the walls, and thus aid

in their destruction. Other plants such as lichens often establish themselves on walls, unsolicited by man, and further aid in rock decay.

Strength.—The strength of stone, viewed from the standpoint of building material, is of two kinds, *crushing* and *transverse*.

Crushing strength has always been regarded as one of the most important properties of building stone. It refers simply to the weight that is necessary to crush the rock, the tests made being usually on inch or two-inch cubes. The results for the same stone vary somewhat according to the conditions under which the tests were made. In preparing samples, care must be taken not to use the hammer or chisel, for they may produce incipient fractures. Sawing or grinding blocks to the desired shape is better. Moisture is another factor, and it has been demonstrated that dry stone has greater crushing strength than when wet. Care must be taken to have the blocks in the same relative positions; thus a cube with the pressure applied on bed may, and usually does, give different results from when the pressure is applied on edge. Experiments in support of this may be found on succeeding pages. Of course, in rocks without bedding planes, such as granite, this might not hold, but the writer is discussing building stones of Ohio and not building stones in general. It has been generally assumed that crushing strength varies directly as size of cube, in other words, that a two-inch cube has four times the strength of a one-inch, but some experiments indicate that strength increases faster than size. This makes it important that comparisons be made on samples of equal size.[1]

While crushing strength of building stone is important, it has been quite generally overestimated. In fact, some have gone so far as to state that durability is directly proportional to crushing strength, but this is now known to be incorrect, for some stone with high crushing strength may be much shorter lived than others whose crushing strength is lower.

Crushing strength, however, is important in lofty monuments and high buildings. Nevertheless, it is much larger in a first-class stone, even in such cases, than the structures require. Thus the base of the Washington Monument sustains a weight of only 314.6 pounds per square inch. At the present time the Woolworth building in New York is the highest structure in the United States. It has 55 stories and rises 750 feet above the pavement. If its walls were constructed entirely of stone, having a density of 2.5, the weight at the pavement, neglecting entirely the effect of the steel frame, would be 813 pounds per square inch. In such buildings, however, much of the weight is supported by the steel skeleton, and this greatly reduces the necessary crushing strength. However, architects demand a margin of safety

[1]For an interesting discussion of this subject see Merrill's Stone for Building and Decoration, p. 474.

of from 10 to 20 times the weight of the structure, and this necessitates in some cases high crushing strength. The following figures give results of tests on some well known building stones:[1]

	Crushing strength Pounds per square inch.
Medina (New York) sandstone	16,262
Berea (Ohio) sandstone	9,236
Dayton (Ohio) limestone	20,000
Bedford (Ind.) limestone	7,790
Quincy (Mass.) granite	17,750
St. Cloud (Minn.) granite	16,000

There is another type of structure in which crushing strength is important, viz.: piers and arches for railroads. Not only is the pressure in such cases large but the suddenness of its application and relief makes the test severe. That the best building stone of Ohio, however, amply meets this demand, has been demonstrated over and again.

The transverse strength of stone has received much less consideration than crushing strength, though it appears to be of equal or of greater importance. By transverse strength is meant the weight necessary to fracture stone when it is supported at both ends. It is customary to use a bar one square inch in cross section, but the length of the bar is less definite. Buckley[2] used lengths of from 4 to 7 inches, but Ries[3] speaks of one inch between the supports, making the mass tested an inch cube. Tests for this bulletin were on pieces four inches long and the distance between the supports was three inches. They were two inches square in cross section. Inadequate transverse strength is shown by cracks in window and door sills and caps, in flagging, in slabs over culverts and in other places.

Color.—While color of stone is important it is largely a matter of taste. The shades of Ohio building stone range from light gray through buffs, yellows and blues to red-brown. Although the color demand has varied from time to time, probably that for brown has been most persistent. Buffs and yellows also have had a large call. Colors, as found in unweathered parts of quarries, are to be regarded with suspicion, since they nearly always change on exposure, and particularly is this true with blue.

The color of Ohio stone is due primarily to iron, the great coloring agent of nature. The state of the iron determines the shade of the stone, and as the latter weathers the color may change. When the iron is in the ferrous state (FeO), the carbonate ($FeCO_3$) or sulphide (FeS_2) blue tints are common. On exposure the iron changes to a higher

[1] Merrill's Stone for Building and Decoration.

[2] Wisconsin Geol. and Nat. Hist. Surv. on the Building and Ornamental Stones of Wisconsin, p. 62.

[3] Economic Geology, p. 105.

oxide, usually $2Fe_2O_3$, $3H_2O$, and with this the color generally becomes buff, yellow or brown. The change may be an improvement, but often the reverse is the case. The sandstone at McDermott, in Scioto County, where unweathered has a blue tint, which on exposure changes to a warm yellow. In this case the change may or may not be an improvement, depending on taste. As might be expected layers near the surface have a yellow shade and those below a blue. Occasionally one finds a block of rock in the quarry with a blue core surrounded with yellow. The dark blue Delaware limestone on exposure changes to buff or yellow and the effect is commonly displeasing. Oddly, the blue limestone that is so extensively quarried at Sandusky, changes on weathering to light gray that is generally admired. The cause of this change which takes place in a short time is not clear. It may be due to oxidation of organic matter, loss of iron, evaporation of interstitial water, or perhaps to all three combined. A change in the color of this stone is noted in a few weeks, but the maximum is not attained for more than a year. The change is uniform.

One of the worst features of change in the color of stone is lack of uniformity. This probably results from variations in the proportion of coloring matter and in the texture of the stone. As a result the wall of a building may show shades of buff, yellow and brown in the space of a few square feet, the effect being very displeasing. Sometimes on weathering, concretion-like patches of yellow or brown appear on smooth surfaces. This is most commonly noted on flaggings but it may be seen on walls of buildings.

Texture has much to do with the appearance, including color of stone. If the stone is open textured it catches dirt readily and its appearance grows darker. Much the same is true if the surface is rough.

Carving.—Carving is promoted by toughness and uniformity in grain. Brittleness and variations in texture or the presence of fossils are undesirable. The Dayton limestone does not carve well, owing to its "plucky" nature, while sandstones like the Berea and McDermott serve admirably for this purpose. Naturally, a body suitable for carving adds to the value of stone.

Ease of Quarrying.—This influences the expense of preparing stone for market. Generally speaking, beds of from 4 to 12 inches in thickness, and with parallel surfaces, are most desirable. Excellent illustrations of these characters are shown in the Euclid and McDermott sandstones, and Cincinnati, Monroe (at Greenfield), Columbus and Delaware limestones. While joints and cracks may be of value in certain rocks, they cannot be much help in sedimentary forms, because it is easy enough to break them. Sometimes thick beds are preferable, as when the stone is to be sawed into thin layers for flagging or for

other purposes. The Berea and McDermott sandstones in part are good illustrations of this. Some stone is practically worthless for building purposes, concrete excepted, if the bedding planes are not well developed. The Cedarville division of the Niagara limestone is a good case in point. Likewise a stone may have little value if the layers are thin and with uneven surfaces, for illustration the Clinton limestone. However, ease of quarrying cannot be said to hold the importance that it did in former years owing to the introduction of channeling machines, power drills, saws and other forms of machinery.

Density.—This increases the cost of labor and transportation and raises the necessary crushing strength. Nevertheless, it cannot be rated high, and in Ohio stone may be wholly neglected.

Architectural Effects.—Sometimes stone may have all the desirable properties enumerated in the preceding paragraphs and still not look well in buildings. This failure in architectural effect is hard to define. The Columbus limestone is a good illustration. Its properties are all favorable but it does not make an attractive wall except in massive structures like the State House. At present architects are using it on a small scale in undressed form for parts of residences, and the effects are much better. Possibly a good market may yet develop for this purpose. The Cincinnati limestone is another illustration of lack of architectural effects, but in this case it is probably due to the numerous fossils which give an unattractive surface.

CHAPTER II

LIMESTONES

THE ORDOVICIAN OR LOWER SILURIAN LIMESTONES AS SOURCES OF BUILDING STONE

The Ordovician or Lower Silurian rocks of Ohio occupy the southwestern part of the State, and according to Orton have an area of about 4,000 square miles.[1] Because of the remarkable display of fossils, the territory has long been a mecca for geologists, but Orton was the first to publish an adequate description of the rocks and their fauna.[2]

As has long been known the strata form a broad anticline or arch whose summit is at or near the village, Pt. Pleasant, Clermont County, 20 miles up the Ohio from Cincinnati. Naturally at this place is exhibited the lowest or oldest rocks that anywhere reach the surface within our State. From the apex of the anticline the rocks dip to the east, west and north, and the slopes are covered with higher and higher formations, as is made clear by inspection of a geological map of the State.

The Rocks

For a description of the rocks under consideration no better plan can be pursued than to quote from Orton.[3]

"This whole series is composed of alternating beds of limestone and shale. The shale is more commonly known under the name of *blue clay*, and this designation is not inappropriate.

"The limestone of the series may, in general terms, be described as an even-bedded firm, durable, semi-crystalline limestone, crowded for the most part with fossils through its whole extent, and often bearing upon its surface the impressions of these fossils. Its color is not uniform, as the designation by which the whole series is familiarly known, viz., *blue limestone*, would seem to imply. The prevailing color, however, may be said to be a grayish blue, chiefly due to the presence of protoxide of iron, which, upon exposure, is converted into a higher oxide. The weathered surfaces generally show yellowish or light gray shades, that are in marked contrast with the fresh fracture. Drab colored courses occasionally alternate with the blue.

"The limestone varies in all these respects somewhat, however, in its different divisions. The Point Pleasant beds, and the lower courses of the Cincinnati division, deviate most widely from the description already given. They are lighter in color than the upper courses, and, in some instances, are slaty in structure, while in others they have a tendency to assume lenticular forms of concretionary origin, sometimes

[1]Geol. Surv. of Ohio, Vol. VII, p. 9.
[2]Ibid., Vol. I, p. 365.
[3]Ibid., Vol. I, p. 373.

to such an extent as to destroy their value as building rock. The layers are also exceptionally heavy, attaining a thickness of 16 or 18 inches, and are often so free from fossils as to afford no indication of the kinds of life from which they were derived.

"A few feet above low water, at Cincinnati, a very firm and compact stone comes in, that is found in occasional courses for 50 or 75 feet. It is composed, as its weathered

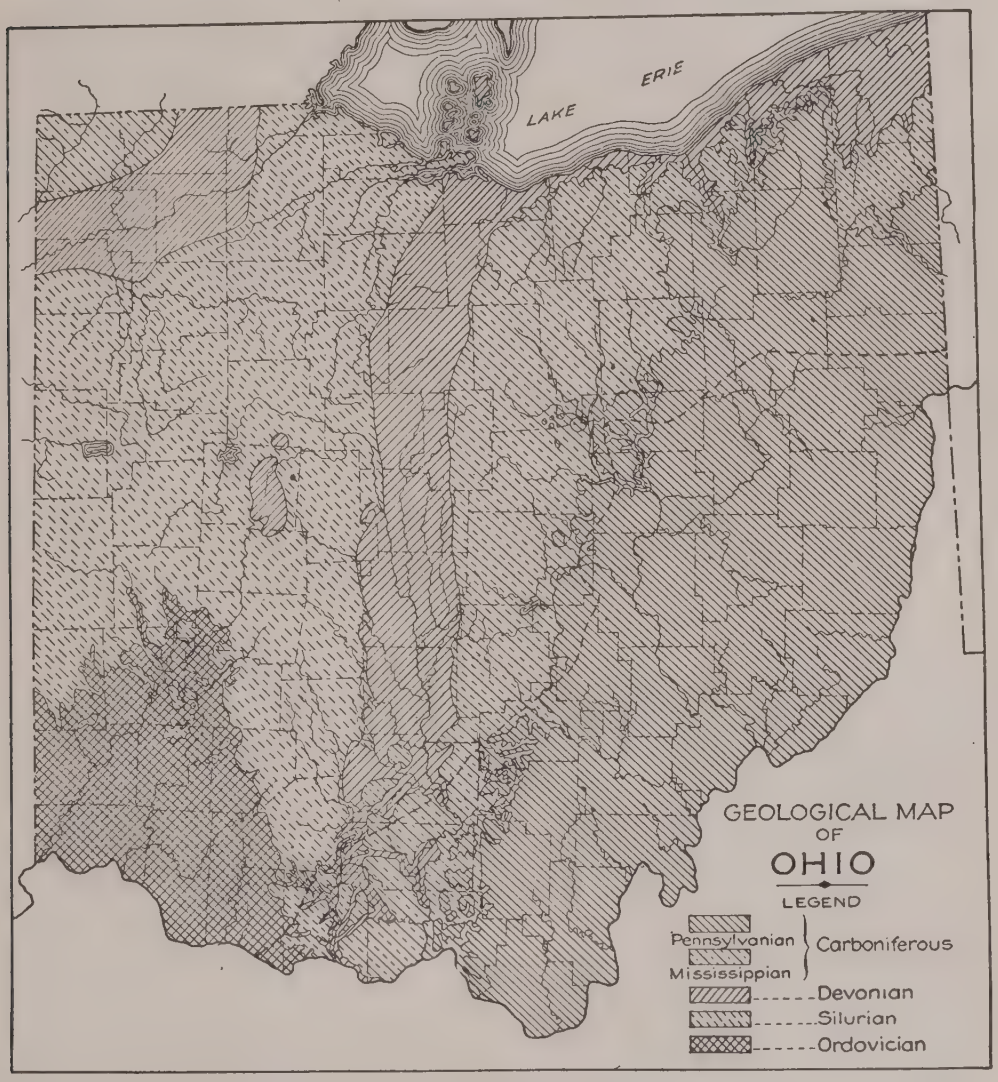


Fig. 1.—Geological Map of Ohio.

surfaces show, almost entirely of crinoidal columns, mostly of small size, and mainly referable to species of *Heterocrinus*. The courses vary in thickness from an inch to a foot. The lighter layers ring like pot metal under the blows of a hammer.

"Ascending in the series, the limestone layers are very generally fossiliferous, and are rarely homogeneous in structure, being disfigured to a greater or less degree by chambers of shale or limestone mud, from some of which cavities, certainly, fossils have been dissolved. The thickness of the courses varies generally between the limits indicated above, but a large proportion of the stone ranges between 4 inches and 8

inches. Now and then, however, a layer attains a thickness of 20 inches, or even 2 feet. Near the upper limits of the formation the layers are thinner and less even than below, affording what quarrymen call a *shelly* stone."

Composition.—This has been determined by numerous analyses. A sample taken at Pt. Pleasant gave Dr. Wormley the following results:[1]

Siliceous matter	12.00
Alumina and iron	9.00
Carbonate of calcium	79.30
Carbonate of magnesium	0.91
	99.21

Peppel collected samples in the vicinity of the Avondale power house on Hunt Street, Cincinnati, and his results follow. As will be observed he covered a long vertical section.[2]

Number of sample	76	72	73	74	75	77	92	93
Description	From top layer down 8 ft.	Next 18 ft. below sample No. 76.	Next 17 ft. below sample No. 72.	Next 17 ft. below sample No. 73.	Next 13 ft. below sample No. 74.	From 85 to 107 ft. below top of quarry.	Next 22 ft. below sample No. 77.	Next 19 ft. below sample No. 92.
Silica	33.60	20.66	30.28	33.08	30.00	36.84	38.00	25.04
Alumina	12.00	7.74	10.30	10.78	9.80	11.14	13.80	9.38
Oxide of iron	3.70	2.10	2.40	2.80	2.30	3.30	2.80	2.80
Carbonate of calcium	43.35	63.70	49.60	46.60	51.45	40.90	38.72	58.08
Carbonate of magnesium	2.65	3.58	4.46	4.19	3.75	4.15	3.80	3.02
	95.30	97.78	97.04	97.45	97.30	96.33	97.12	98.32

One more analysis will be given and this is of the highest division of the Cincinnati strata, the Lebanon beds of Orton, or the Richmond as they are now known:[3]

Only the calcium and magnesium carbonates are shown:

Carbonate of calcium	91.50
Carbonate of magnesium	5.06
	96.56

[1] Wormley, T. G., Geol. Surv. of Ohio, Vol. I, p. 374.
[2] Peppel, S. V., Geol. Surv. of Ohio, Fourth Ser., Bull. 4, p. 72.
[3] Wormley, T. G., Geol. Surv. of Ohio, Vol. I, p. 374.

Classification

The surface rocks of the great area under consideration have a thickness according to Orton of 750 feet,[1] and to them the name Hudson River was early given because they were supposed to be of the same general age as certain strata exposed along that stream.

Later the name Cincinnati was applied to the formations. It has the advantage of location and does not commit the geologist to any relationship to formations elsewhere. The subdivisions of these rocks have been a mooted question from the time of Orton's comprehensive description, to which reference has already been made, to the present time. Apparently general agreement is still far off. In this bulletin Prosser's classification, which follows, is adopted.[2]

4. Richmond formation.
3. Lorraine (Maysville) formation.
2. Eden shale.
1. Trenton limestone (Pt. Pleasant beds).

PT. PLEASANT BEDS

Orton seemed to think that the area of outcrop of these beds was limited to the vicinity of the village from which they were named; at any rate that they were not found in the river valley at Cincinnati but about 50 feet below it,[3] but Winchell, Ulrich and Nickles class the lower 50 feet of rocks, exposed in the Ohio Valley opposite that city, with the Trenton, and assign the beds at Pt. Pleasant to the same great formation. From this it appears that the rocks are of the same age. Orton regarded the Pt. Pleasant beds 50 feet thick while Foerste assigns just twice that figure.[4]

The beds of limestone near Pt. Pleasant vary in thickness from about 1 inch to 2 feet. Perhaps the latter would split into two or more layers if removed from its place. However, beds more than 6 inches in thickness are not common. As a rule the surfaces of the stone are quite even, and in fact this may be said to be characteristic of the limestones of the entire Cincinnati division. Freshly quarried blocks show colors ranging from dark-gray to blue, with a texture that may be distinctly crystalline or but slightly so. Two or more layers contain concretionary-like masses, of elongated but irregular shape, whose greatest diameter may reach 3 feet. Some of these show no

[1]Ibid., Vol. VII, p. 8.
[2]Prosser, C. S., Geol. Surv. of Ohio, Fourth Ser., Bull. 7, p. 4.
[3]Geol. Surv. of Ohio, Vol. I, p. 370.
[4]Foerste, A. F., Science, N. S., Vol. XXII, p. 151.

resemblance to concretions except in their shape, while in others the reverse is true. Very little was seen of the strata below the concretionary beds.

The quarries near Pt. Pleasant are very small and have never been of importance. No work at all was in progress when they were visited in 1909, and quarrying practically ceased in 1904. However, the hills in that vicinity would yield inexhaustible supplies of stone for building and other purposes, if shipping facilities were had and market conditions were favorable.

About two and one-half miles up the Ohio from Pt. Pleasant is the village Moscow, and across the river from this place is the Ivor quarry, the largest in the Ohio Valley in the vicinity of Cincinnati. When the quarry was visited in 1909 a ledge of more than 80 feet was being worked. It terminated below with the base of the "boulder" or concretionary beds, which measure from 3 to $4\frac{1}{2}$ feet in thickness, and lie about 70 feet above the low water mark of the river. The "boulders," which attain a maximum length of 4 feet, show nothing of the concretionary structure; they are fine grained, compact, hard, have a dark color and are crushed for ballast, etc. While the proportion of limestone is unusually large in this quarry at least one-third of the material is shale and has to be thrown out.

Two courses deserve special mention. About 20 feet from the top of the quarry is the "Cliff ledge," consisting of two layers each 10 inches in thickness, which is of superior quality, and is used for various building purposes. Thirty feet lower is the "Tough ledge," 12 inches thick and of dark gray color. It is a good cutting stone and is reported to have been used in the piers of the Cincinnati Southern railroad bridge at Cincinnati. These courses constitute the best building stone found in this territory.

Formerly the stone was shipped to Ashland and Newport, Kentucky, as a flux in iron making, but the market for this purpose is something of the past. Now its market is for concrete, macadam, ballast and building stone. Quarrying in this vicinity is said to have been done for the last 50 years. The stone of this quarry is largely dark blue in color, but occasional layers of brownish-gray are found. Nearly all are less than 8 inches in thickness.

The courses that were formerly worked near the river at Cincinnati were named the River Quarry beds by Dr. Orton, and as has already been mentioned, were regarded by him as lying above those exposed at Pt. Pleasant. Now it is claimed by special students of the problem that the two are part of the same formation, the Trenton limestone.

EDEN SHALE

Lying above the "River quarry beds" at Cincinnati are 250 feet of blue clay or shale containing a small quantity of thin-bedded limestone, to which Orton gave the name Eden shale from the fine exposures then had in Eden Park. His description of these follows:

"The shales, as implied in one of the names by which they are known, *blue clay*, are generally blue in color, but the shade is lighter than in the limestone. In addition to the blue shales, however, drab-colored clays appear in the series at various points. As the blue shales weather into drab by the higher oxidation of the iron they contain, the conclusion is frequently drawn that the last named variety marks merely a weathered stage of the former. But aside from the impossibility of explaining the facts as they occur on this hypothesis, analysis disproves it, and shows that the differences in color are connected with essential differences in the composition of the belts to which they belong * * *.

"Most of the shales slake promptly on exposure to the air, and furnish the materials of a fertile soil; but there are other portions included under this general division which harden as the quarry water escapes, and become an enduring stone if protected from the action of frost * * *.

"The proportions of limestone and shale in the series have been already spoken of in a general way, but it will be profitable to give additional statements on this point. In the river quarry beds, the lowermost portion of the Cincinnati beds proper, there are about four feet of shale to one foot of limestone, but the shales increase in force as we ascend in the series, until at about one hundred feet above low water the proportion is more than twice as great. For the two hundred feet next succeeding, that have been styled the *Eden Shales or Middle Shales*, there is seldom more than one foot of stone in ten feet of ascent. The amount of waste is so large, therefore, that quarries cannot be profitably worked in this whole division. The third portion of the series, the Hill quarries, have for their lower limits the beds in which the solid rock has risen again to as high a proportion as one foot in five or six feet of ascent. From this point upward to the completion of the group, there is no such predominance of shale as is found below, though in the lower parts of the Lebanon beds, shales still constitute more than one-half of the whole thickness."

LORRAINE FORMATION

This overlies the Eden shale, and appears to include the rocks to which Orton applied the name "Hill quarry beds," having a thickness of 125 feet. The formation differs from the underlying one (aside from the fossils) in the larger proportion of limestone. This has been quarried at numerous places near the hill tops at Cincinnati and down the river well toward North Bend. When the territory was visited in 1909, two or three small quarries were found in operation. Two were on opposite sides of the Hamilton Road north of Cumminsville, and showed a vertical section of about 80 feet. Clay exceeded the limestone in approximately the proportion of 4 to 1. The limestone was thin bedded and was used for crushing, though its demand for building stone was reported good. In the Miller quarry on the Bracken Road in Mill Creek Township, a ledge of 30 feet was found, the lime-

stone and clay being in about equal proportions. The thickest ledge measured 8 inches and the chief use of the stone was for building purposes. The Lorraine formation contains a great quantity of stone that may be used for building or for crushing, but the large percentage of clay or shale makes it expensive to work.

RICHMOND FORMATION

This marks the summit of the Ordovician in Ohio and has an outcrop of perhaps 2,000 square miles. Like the Lorraine it consists of shales and limestones in varying proportions, and was assigned a thickness of 300 feet by Dr. Orton, who gave the formation the name "Lebanon beds" from the exposures near that city. Later, it having been found that this name had been previously used in Tennessee for a different formation, the name Richmond was proposed and is now in general use among geologists. The Richmond and Lorraine formations are much alike in their rock content, and for our purposes might as well be considered one.

The most extensive quarry of the Richmond formation was found near the west end of the Columbia Street bridge at Hamilton, Butler County, but no work was being done when it was visited in 1909. A bluff of about 80 feet was exposed, and the proportion of limestone in it was unusually large, especially of the thicker courses, though none in excess of 10 inches was noticed. A few hundred yards farther down the river is Myer's quarry, where a bluff of 75 feet was found, one-third of which the proprietor estimated to be marketable stone. A layer of 20 inches was found but this was not persistent. Like the preceding quarry, all was quiet, the competition of concrete being too much. Near Myer's quarry is Pabst's which was being opened in 1909.

The quality of the stone in the vicinity of Hamilton is characteristic of the Cincinnati rocks in Southwestern Ohio. It has the dark blue color, is thin, even bedded, highly fossiliferous and quite hard. As building stone it is not surpassed by the same formation in southwestern Ohio.

Building Stone

Facts concerning the distribution, character, composition and classification of the Ordovician rocks in Southwestern Ohio have now been given. References have been made to them from time to time as building stone, but for clearness certain facts will be stated though they may have been given before.

The one great factor that favors these rocks for building stone is their thin, even beds. While these may attain a thickness of 2 feet (Pt. Pleasant quarry), such measurements are extremely uncommon,

and one may examine vertical exposures of 60 feet or even more without finding a single layer as much as 12 inches thick. Another element favorable to the stone is its crushing strength. When laid on bed it meets in this respect the severest test that has yet been made by the architect or engineer. Further, it withstands as trying a climate as is demanded of any stone, and we may add that when thinness of bed, crushing strength and durability are leading factors, the stone under consideration may be selected without fear. Chert and pyrite, common impurities in limestone, are both very rare or wanting.

There are several objections to the stone, and first of these is its color. Blue is an unsafe color in stone for it results from the iron, usually in the form of ferrous oxide, which on exposure changes to the ferric state, and this is accompanied by a color change, often to buff or yellow. If the resulting shade were uniform the result might not be bad, but sometimes the wall appears mottled and the general effect is not pleasing. The gray or gray-brown layers should be safer, since they undergo less color change.

As a rule rocks with numerous well preserved fossils are objectionable for building stone. When large they may roughen the surface, weather unequally and vary the color. Nearly always they prevent carving. In the case of the rocks of the Cincinnati group the fossils are highly objectionable for they are wonderfully numerous and well preserved and very often of large size. Frequently they may be seen projecting from the face of the layers and the effect is bad. They render the rock unfit for carving, but probably its somewhat brittle nature alone would do that.

When laid on edge, the layers shell badly, but almost any sedimentary rock will do that, the differences being largely one of degree. On this account the rocks of the Cincinnati group are not well adapted for curbings or any other structure where the strata cannot lie on bed.

Viewed from the standpoint of quantity the supply may be said to be inexhaustible, for the formations outcrop over about 4,000 square miles of our State. It is important, however, to keep in mind the large proportion of clay that must be handled in getting the stone. Rarely does the latter comprise 50 per cent of the mass and often it is less than 25. Naturally this greatly increases the expense of quarrying.

When the territory was revisited in 1913 not a quarry in operation was found in Clermont, Brown or Warren counties, and only two or three small ones in Hamilton County, and one in Butler. These facts indicate the small part that this great formation now plays as a source of building stone.

Cincinnati has always been the one great market for the rock where it has been used for buildings, foundations, retaining walls and

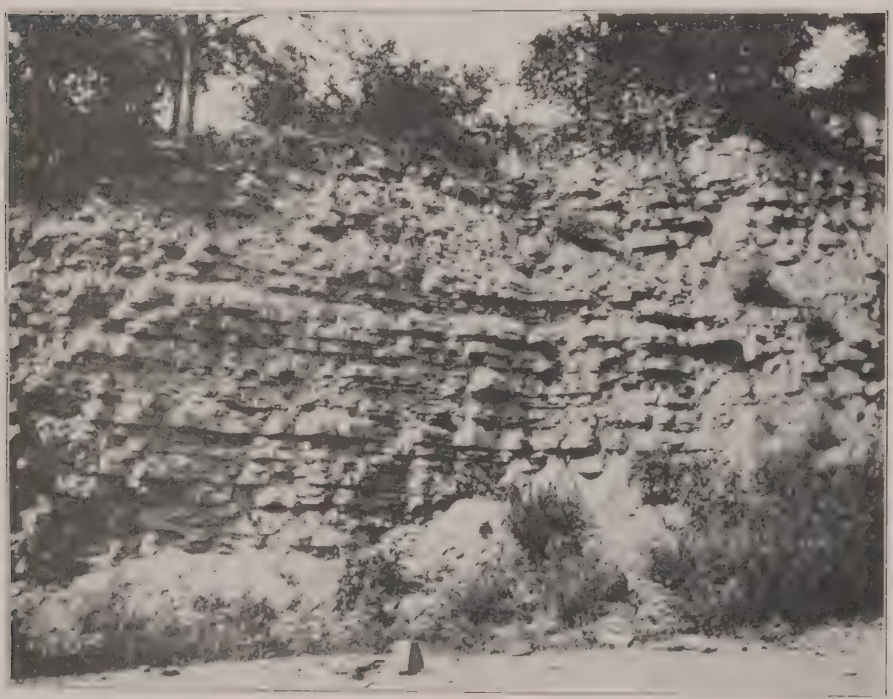
curbings. It has been extensively used for walls of churches, and to a lesser extent for residences. At first entire walls were constructed of this stone but the effect was rather monotonous. Later sandstone was used for trimming and this has added to the attractiveness. Still under the most favorable conditions the stone has not been able to meet the competition of sandstones like those from the McDermott quarries in Scioto County, Ohio, and the Bedford limestone of Indiana. Apparently its day as a building stone is over, though no one can tell what the market will be a generation or two hence. The principal quarries were along the low water line of the river and near the hill tops in the vicinity of Cincinnati. Later much stone was gotten on the river bank opposite Moscow, Ohio.

In arriving at a fair estimate of its qualities as building stone, no better plan can be taken than to examine some of the walls constructed of it. The Church of the Assumption on Walnut Hills was built in 1885 of Cincinnati limestone, with steps of sandstone. The tower contains a square of irregular pieces of granite. The dark colored mortar and gray walls give a rather pleasing effect. Not one layer, having a blue color, was observed in these walls, which were undamaged by their many years exposure. The blocks of limestone vary in thickness from 12 inches to 2 or even less. Those highly fossiliferous weather to an uneven color, but that is apparent only at close range. The rather shaly, non-fossiliferous layers weather more uniformly and a little darker. Sometimes these develop a banded structure, but this is not noticed when the observer is a few feet away. Occasionally a block stands on edge, which weathers to a lighter shade than the surrounding pieces and shells off.

The First Presbyterian Church of Walnut Hills was erected in 1879 of Cincinnati limestone, and trimmed with sandstone. The limestone gives evidence of having been selected with care. Those beds with many fossils are rather faintly spotted owing to the darker shade of the fossils. The color of the walls is a moderate gray, without one block having the tint that is usually found when the rock is quarried. Occasionally the mortar has fallen, and dust collecting in the cracks gives a ragged and disagreeable effect. Good mortar is unusually important where this limestone is used because the thin layers of stone make the proportion of mortar in the walls decidedly large.

St. Francis de Sales, an imposing church at the intersection of Woodburn Avenue and Madison Road, was constructed about 1880 of Cincinnati limestone, with extensive trimmings of sandstone that resembles the Buena Vista The limestone has weathered to gray, and the only damage done thus far by the elements has been to shell an occasional piece. The trimmings have colors which range from gray to brown and give a spotted appearance.

A.—Art Museum (right) and Art School, Cincinnati.
Built of Cincinnati limestone.



B.—View of Cincinnati limestone and shales (Lorraine formation), Cincinnati.
Note the large proportion of shales.

The front or principal part of the Art Museum, constructed nearly 30 years ago, is of Cincinnati limestone trimmed with dull pink granite. The stone was carefully selected and the basement is of courses that vary from 9 to 15 inches in thickness. Frequently they contain pebbles of the non-fossiliferous variety of the stone and these may lie parallel to the bedding planes or at an angle to them. Usually the pebbles are darker than the enclosing rock.

Most of the stone is fossiliferous but layers of the non-fossiliferous are common. The latter are usually darker than the body of the wall but sometimes the reverse is true. Occasionally they develop a banded effect on weathering, and what is much worse, show a marked tendency to split into thin shale-like layers. Sometimes the two varieties—fossiliferous and non-fossiliferous—appear in the same block, the line of junction being prominent but the two parts are firmly united.

Crystals of pyrite were occasionally noted, and brown spots common. The general result is to give the walls a decidedly mottled effect, much more so than has been observed in any other structure. All in all the stone has not proven satisfactory for a rear wing of the building that was constructed later is of Bedford limestone. Standing near the Art Museum is the Art School, built of Cincinnati limestone, and trimmed with dark brown sandstone with a red tile roof, the whole giving a pleasing effect.

On Riverside Drive is an old residence that was built in 1847, but no longer inhabited. The limestone walls are still in good condition though the mortar is much the worse for wear.

The seventeen-span viaduct leading to the Cincinnati, Hamilton & Dayton railroad bridge at Hamilton is of Cincinnati limestone, reported to have been gotten from the surrounding hills, and trimmed with Dayton stone. It is still well preserved and looks good for another half century.

The illustrations cited might be almost indefinitely extended, but the facts would be repetitions of those already given.

THE SILURIAN ROCKS AS SOURCES OF BUILDING STONE

Reference to a geological map of the State (Fig. 1) will show that these rocks constitute the surface formations of the western half of Ohio, with the exceptions of the Ordovician in the southwestern part, and about 1,800 square miles in the northwestern corner. The rocks consist of limestone with a subordinate quantity of shale and sandstone. They have been subdivided as follows:

Monroe formation.	Clinton limestone.
Niagaran series.	Medina shale.

THE MEDINA SHALE

Lying along the outcrop of the Ordovician rocks in Southwestern Ohio is a bed of shales having a thickness, according to Orton, of from 10 to 40 feet.[1] Their color is usually "red or yellow" and they were for a long time looked upon as of Medina age. Recent studies by Foerste and others have thrown this determination in doubt and their placement may be considered a somewhat open subject.

It may be worth while to state in this connection that in Northwestern Ohio the drill has shown the presence of a bed of shales from 50 to 150 feet in thickness and usually of red color. These directly overlie the Ordovician rocks, and hence have the position of the Medina. Deep wells in Central Ohio have given similar results, but the shales contain a bed of sandstone from a mere film to 50 feet or more in thickness which yields gas in wonderful quantity, and to a much smaller, yet important extent petroleum. This valuable bed has long been called the Clinton sand but its proper assignment seems to be with the Medina.[2] Facts such as those just given lead the writer to believe that the Medina formation is present wherever due in Ohio, but that it changes its character and thickness to the southwest, the oil and gas sandstone disappearing in the longitude of Columbus, and the shales becoming thin and unimportant along their line of outcrop in Southwestern Ohio.

Certain it is that the formation in question nowhere yields building stone within Ohio, and for that reason it will receive no further notice in this bulletin.

THE CLINTON LIMESTONE

This outcrops along the line of junction of the Ordovician and Silurian in Southwestern Ohio. It lies above the Medina shales and below the great Niagara group. Under cover it has been disclosed by the seeker for oil or gas in hundreds, yes thousands of wells in Northwestern and Central Ohio.[3]

Along its line of outcrop it has, according to Orton, a thickness of from 10 to 50 feet. Usually it is distinctly crystalline, so much so in places that it has been mistaken for marble. Its colors are of light shades, gray, white, pink, red and blue, and are often very attractive. The following analyses, by the late Professor N. W. Lord, show its composition:[4]

---

[1]Geol. Surv. of Ohio, Vol. VI, p. 9.

[2]Bownocker, J. A., Economic Geol., Vol. VI, p. 37.

[3]Orton, Edward, Geol. Surv. of Ohio, Vol. VI, and Bownocker, J. A., Geol. Surv. of Ohio, Fourth Ser., Bull. 12.

[4]Geol. Surv. of Ohio, Vol. VI, pp. 728-729.

Sample from New Carlisle, Clark County

Calcium carbonate	96.80
Magnesium carbonate	2.07
Alumina and iron	0.29
Siliceous matter	0.83
	99.99

Sample from near Piqua, Miami County

Calcium carbonate	95.03
Magnesium carbonate	4.35
Oxide of iron, Alumina	0.26
Silica	0.45
	100.09

Analyses might be given from various places but with little difference in results. The rock is a calcareous limestone of unusual purity, the most so in fact of any formation in the State. It is soft and easily worked, but has one objectionable quality as a building stone—it nowhere lies in even beds. They are lenticular shaped and hence require much dressing, and this has kept the stone from being used in the large way for buildings that its crystalline nature and colors warrant.

The largest quarries appear to have been on the grounds of the Soldiers Home near Dayton, one where the grotto now stands and the other in the deer park. Much stone was secured from these places in constructing the extensive buildings of the Home. The National Asylum Church is built of the Clinton limestone. It has weathered to a gray color and the general effect is not very attractive. In other words the stone has deteriorated in appearance on aging. The stone has had a larger use for foundations, but at present the calls are for crushing, flux and marble dust. The stone is too soft for first-class road material and it is no longer burnt for lime.

At Piqua a ledge of 21 feet of the Clinton limestone is now quarried. Formerly it was used on a rather large scale for foundations and trimmings, but this has been discontinued. It is reported to have been used in the canal lock about two and one-half miles south of Piqua, and though this was done 75 years ago the stone is still in good condition. The stone is now used for flux, macadam, marble dust, etc.

THE NIAGARA LIMESTONE

The Niagara group of rocks, consisting of limestones, and to a much smaller extent of shales and sandstones, forms two separate

areas in Western Ohio. The larger one borders the Ordovician or Lower Silurian group in the southwestern part of the State, and alone yields building stone of high grade. The second area is in Northern Ohio and is surrounded by the Monroe formation which will be considered later.

The Niagara rocks of Ohio have been subdivided by various geologists whose results in the main are in agreement. The following classification by Professor Prosser is adopted for this bulletin:[1]

Hillsboro sandstone.
Cedarville limestone.
Springfield limestone.
West Union limestone.
Osgood beds.

THE OSGOOD BEDS

These beds outcrop along the line of junction of the Ordovician and Silurian in Southwestern Ohio. Dr. Orton who called them the Niagara shale described them as "a mass of light colored clays with many thin calcareous bands." He assigned them "a thickness of one hundred feet in Adams County," but stated that they contract rapidly northward, measuring only 10 or 15 feet in Clark and Montgomery counties. "Still farther to the northward, as appears from the records of recent drillings, the shale sometimes disappears entirely; but in the great majority of the wells, especially in Hancock and Wood counties, it is a constant element, ranging from five to thirty feet." In Central Ohio the shales, as shown in hundreds of deep wells, are almost if not always absent, the Niagara limestone resting directly on the Clinton from which it can be readily separated by its composition, crystalline nature and color.[2] "In Montgomery, Miami and Greene counties," writes Dr. Orton, "the shale contains, in places, a very valuable building stone, which is widely known as the Dayton stone. It is a highly crystalline, compact and strong stone, lying in even beds of various thickness, and is in every way adapted to the highest architectural uses."[3]

When newly quarried the Dayton stone is a light gray with just a trace of blue which disappears on weathering. It is unusually compact and strong, and quite even bedded. Only one objection can be raised against it—the presence of iron pyrite. Crystals of this metal may be present in large numbers and a half inch or more in diameter,

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 7, p. 4.
[2]Bownocker, J. A., Geol. Surv. of Ohio, Fourth Ser., Bull. 12, p. 27.
[3]Ibid., Vol. VII, pp. 11, 12.

but in places they may be small or rare and even wanting. When stone containing these crystals is exposed to the elements, they decompose leaving a dark cavity in the rock and sometimes a brown or black spot below. Aside from these crystals, the Dayton is probably the most durable limestone in Ohio. In addition its crushing strength is remarkable, being ample for the loftiest "skyscrapers" that present day architecture demands.

The compostition of the Dayton limestone is intermediate between the underlying Clinton and the higher parts of the Niagara, but it resembles much more the former than it does the latter. A sample taken from the old McDonal quarries in Greene County gave the following results:[1]

Calcium carbonate	84.50
Magnesium carbonate	11.16
Alumina and iron	2.00
Silica	2.20
	99.86

The area underlain with the Dayton limestone is large, amounting at least to hundreds of square miles, and hence the supply is practically inexhaustible. However, it is available only where the overlying members of the Niagara group are wanting and where the drift is thin. This practically limits quarrying to the line of junction of the Ordovician and Upper Silurian.

While stone has been worked at numerous places in former years, the quarries have nearly all been small. These will now be reviewed.

Centerville.—The quarry near this village shows the Osgood beds with the Dayton limestone in excellent development as follows:

	Ft.	In.
Glacial drift	3–12	--
Niagara limestone.		
Osgood beds: Shales, 4 ft.		
Osgood beds: *Dayton limestone*, 5 ft.	10	6
Osgood beds: Clay, 1½ ft.		
Clinton limestone	18	--
Medina (?) shales	18	--

Since the Dayton limestone alone concerns us in this discussion no further reference will be made to the other members of the above section. A detailed section of the Dayton stone is given below:

[1] Wormley, T. G., Geol. Surv. of Ohio, Vol. II, p. 669.

	Ft.	In.
"Buff and gray" stone, usually in two beds, the lower about twice as thick as the upper, but sometimes in 3 or 4 layers of approximately the same thickness	1	6
"Yellowback" course	--	10
Eighteen-inch layer	1	6
Thin layer	--	3–4
Bottom layer	--	9–10

The "buff and gray" courses have surfaces of yellow or buff color which may extend into the rock 3 inches, and when the layers are thin reach through them. Elsewhere the usual color of the Dayton stone prevails. This stone cannot be quarried in winter, but when gotten out in summer and seasoned it is durable. However, its use is now limited to foundation purposes.

All the courses below the "buff and gray" are stronger, and may be quarried in winter as well as during other seasons. The massive 18-inch course is sawed into layers for trimmings, such as sills, caps and steps. For the latter purpose the stone is the most satisfactory in Ohio, yielding very slowly to wear and being of attractive appearance. It is the only limestone in Ohio that is sawed. Formerly the course was split into layers of desired thickness. The surfaces of the several beds are rough, and when joints of walls are to measure three-quarters of an inch, the projecting points only have to be knocked off, but if they are to be narrower more work is required.

The Centerville quarry was opened in the early days of the county, but was not worked regularly until about the year 1860. Three or four years later the place is reported to have been abandoned until perhaps 1880, when work was again resumed and has been in progress ever since with the exception of two or three years.

Two quarries formerly existed at Centerville. One was abandoned about the beginning of the Civil War, while the other one, which according to reports, was opened in 1870 was closed in 1907. In these two quarries the amount of stripping varied from 2 to 10 feet. The stone is of similar quality to that in the quarry near Centerville but the quantity is less, the beds thinning to the southward.

Dayton.—The Dayton limestone is well developed in the vicinity of Dayton where it long had a ready market. In 1870 five firms were quarrying the stone in that vicinity, the combined output being large. One firm alone handled more than 9,000 perches in 1869.[1] Land underlaid with this rock sold for $2,800 per acre, the title to the land not being lost by the seller. The area underlaid in the vicinity of Dayton is large, but the drift covering is rarely less than 5 feet and this greatly increases the expense of quarrying.

[1]Orton, Edward, Geol. Surv. of Ohio, Rept. of Progress for 1869, p. 153.

Old (left) and new Court Houses at Dayton, built of Dayton limestone.

The largest quarries seem to have been near the village Beavertown. When work first began there is not known, but Thomas Tirney informed the writer that when he moved to that locality in 1853 the stone was being quarried for the Court House at Cincinnati, this being the structure that was burnt during the riot of 1884. Probably the industry began in this vicinity in the early days of the county's history. A good section of the stone was not exposed but J. Sullivan, who states that he worked in the quarry from 1875 to 1903, gave the following:

Dayton limestone.	Ft.	In.
Yellow stone of poor quality. Used for walls and foundations. Splits into 3 or 4 layers	1-1	4
"Yellowback" course	--	9–13
Six-inch course	--	6
Twenty-inch course. Could usually be split into two layers	1	8
Four-inch course	--	4
Twelve-inch course	1	--
Clay, unmeasured.		

Quarrying on a large scale is reported to have closed in 1897 and the works were abandoned about 1903. The quantity of Dayton limestone that remains in the vicinity of Beavertown is very large but the covering makes it inaccessible.

A quarry formerly existed near the State Hospital, where, according to L. W. Green, Superintendent Dayton Limestone Company, the layers are as follows:

Dayton limestone.	Ft.	In.
Eight-inch course	--	8
Six-inch course	--	6
Twenty-inch course	1	8
Sixteen-inch course. This splits into 2 or 3 layers which seem to represent both the Four and Twelve inch courses at Beavertown	1	4

While the market for this stone extended from Toledo to Columbus and Cincinnati and to Indiana, naturally the chief demand was from the city Dayton, where it was used in some of the finest structures, and for curbings and flaggings. Among these buildings may be mentioned the old Court House built in 1850, new Court House erected in 1884, Third Presbyterian Church, Grace Methodist Episcopal Church, Sacred Heart Church (trimmed with dark brown sandstone), First Presbyterian Church and the Library Building (trimmed with light brown sandstone) in Cooper Park.

The structure and properties of the Dayton stone in the vicinity of Dayton is similar to that already given for Centerville. That it

withstands the severe test of climate is shown by the walls of the old Court House which are still in excellent condition after 65 years exposure. The objectionable pyrite is common, and in the walls just referred to bright crystals and brown or black spots may be found a few inches apart in the same block of stone. Sometimes the spots look like rusty nail heads.

The library building in Cooper Park, which, as already stated, is built of Dayton stone and trimmed with Lake Superior sandstone, shows the former variety undamaged while the sandstone in places is crumbling badly.

Jasper.—Four or five miles east of Xenia is a quarry where the Dayton limestone has been worked for a half century or more. A few years ago 75 men are said to have found employment, but more recently the number has dropped to a dozen or less and even these have not had steady work. The quarry shows over 20 feet of Clinton limestone in characteristic color, texture and structure, that is used for crushing. This is overlaid directly by the Dayton stone of which the following is a section:

	Ft.	In.
Drift	5	--
Dayton limestone.		
Shale, clay and thin bedded, yellow brown limestone	2	6
Light blue-gray limestone in thin layers. Used for building stone and formerly for flagging. Changes rapidly in total thickness as well as in that of the several layers: 4 in., 2, 2, 4, 4½, 4	1	8½
Used for building purposes. Sometimes splits into 2 layers	--	9
Used for building and flagging	--	4½
Sometimes splits into "two-eights." Used chiefly for range work	1	4
Used for building and flagging	--	4
Used primarily for range work	--	9
Clinton limestone	20	6

These beds are separated by layers of clay from a film to an inch in thickness. The massive 16-inch course contains some pyrite, especially in its lower half. All of the layers from the nine-inch down have the properties of the Dayton stone as previously described, and seem to be first class for buildings. Layers above this course weather to a buff or light yellow. Much of the stone has been used for curbing and Xenia and Dayton have been the principal markets for the output.

Formerly a quarry of importance was located on the McDonald farm, three and one-half miles south of Xenia, where from four to

eight feet of good stone in layers of from four to 20 inches was found. The output in the main was hauled in wagons to Xenia and from there shipped by rail, but this handicap proved too much and the quarry was abandoned many years ago. The Dayton stone has been quarried at other places in Greene County, especially near Harbine's Station.

THE SPRINGFIELD AND WEST UNION LIMESTONES

The West Union limestone rests directly on the Osgood beds and in turn is overlaid by the Springfield limestone. In places these two divisions cannot be readily separated, and for that reason they are considered together in this bulletin.

The Springfield limestone usually is even bedded, with layers that vary in thickness from a few inches to several feet. The rock appears earthy rather than crystalline, is quite porous and often contains perceptible cavities. Chert is occasionally found, but it is confined to certain beds and not distributed promiscuously through the rock. While pyrite is present it is rarely so common as to mar the value of the stone. In color the variation is from light-blue to buff and even yellow. Generally the latter shades are found near the top, while the light-blue is present in the lower courses, and even there commonly exists as spots mixed with buff, rather than as continuous beds. This suggests that the buff or yellow color has resulted from the oxidation or weathering of the light-blue.

The West Union limestone is more massive than the Springfield and of practically no value as building stone. In a few places it is crushed for ballast, concrete and road making, but it plays very little part in the stone industry of Ohio.

In composition the rock forms a marked contrast to underlying formations. This is well shown by the following analyses when compared with those given on preceding pages.

Lower or West Union Cliff, near Hillsboro

Calcium carbonate	62.60
Magnesium carbonate	31.32
Alumina and iron	3.20
Siliceous matter	2.60
	99.72

In the same locality the Springfield stone or "Blue Cliff" gave the following :[1]

[1] Wormley, T. G., Geol. Surv. of Ohio, Rept. of Progress for 1870, pp. 274-5.

Calcium carbonate	35.57
Magnesium carbonate	49.00
Alumina and iron	2.00
Siliceous matter	13.30
	99.87

At Yellow Springs, Greene County, the Springfield stone has the following composition:[2]

Calcium carbonate	51.10
Magnesium carbonate	41.12
Alumina with trace of iron	1.40
Silica	5.40
	99.02

These analyses, which might be duplicated in large numbers, indicate a magnesium limestone, and in fact the composition sometimes approaches a dolomite.

The Springfield and West Union beds, and particularly the former, have been quarried from the time of the pioneers at numerous places in Southwestern Ohio. The principal localities where work is in progress will now be discussed.

Springfield.—This has long been the place where the Upper Silurian limestones have been most extensively worked in Ohio. The quarries, however, are not at Springfield, but a few miles to the southwest in the valley of the Mad River. For several decades the only output was lime and building stone, but in recent years the latter has become very small while the production of crushed stone has assumed large proportions. Flux also is shipped freely, and occasionally a carload of material for agricultural purposes. Numerous kilns still produce lime in great quantity and of excellent quality. In fact it is one of the important centers for this industry in the United States.

In the quarry of the Mills Brothers, on the east side of Mad River, the following section was measured:

		Ft.	In.
Drift		4	--
Niagara limestone.			
Cedarville limestone. Used for lime and crushing		18	--
Springfield limestone. Used for building and curbing. Color buff or yellow. Beds even and sometimes have stringers of chert. No pyrite seen	6 in.	5	8
	7		
	7		
	12		
	12		
	8		
	12		
	4		

[2]Ibid., Vol. II, p. 672.

		Ft.	In.
Springfield limestone. Used in bridge work. Contains some chert	16 in. 6 14 18 18	6	--
West Union limestone. Used for crushing		10	--

Farther south on the same side of the river is the quarry of the Strunk-Meyer Lime Company, where the rocks are as follows:

	Ft.	In.
Glacial drift	2-8	--
Niagara limestone.		
Cedarville limestone or "cap rock." Used in making lime and as flux	23	--
Springfield limestone, suitable for building purposes. Now used for crushing	14	8
West Union limestone, the "bed rock" or "second cap" of the quarrymen. Upper four and one-third feet massive, with thin uneven layers below. Not suitable for building stone. Never worked	9	5
Osgood shale, top only seen.		

The above section is interesting because of the divisions of the Niagara shown. The quarry is reported to have been opened about 1846 for burning lime. Building stone was gotten out from time to time, but about 1907 the demand became so small that quarrying for this purpose ceased.

On the west side of Mad River the land is higher, and hence more of the Cedarville division is shown, in one case as much as 65 feet, but the quarries do not extend deep enough to uncover the lowest rocks of the Silurian.

As long as there was demand for building stone, the Mad River quarries produced it in large quantity. During the past 20 years the market has declined, so that at present the output is very small, the courses formerly used for this purpose now finding their way to the crusher. In fact a quarry of the Mills Brothers is the only one in which these beds are saved for their time honored use.

While the stone has enjoyed a large market, especially in Southwestern Ohio, the principal demand has been from Springfield. Among the more important structures erected from it in that city may be mentioned the P. P. Mast residence (trimmed with sandstone), Masonic Home, Christ Episcopal Church, and Snyder Memorial Arch. Christ Church, mentioned above, was erected in 1872, and though not from selected stone shows very little shelling or crumbling. Solution work has been more active, producing in places a slightly honey-combed effect. These depressions are of lighter shades than the surrounding

rock. The color of the walls is not uniform, ranging from buff, through grays to near black. The steps and water table show much chert. In places this has been knocked out from the steps, leaving holes, while in other places it projects beyond the general surface, doubtless a result of differential weathering. Generally the line of junction of the chert and limestone is marked by a sharp depression, owing to the larger surface exposed to the atmosphere with its solvents. Practically speaking these walls are as good as when constructed, 40 years or more ago.

Fig. 2.—Snyder Memorial Arch at Springfield, built of Springfield limestone.

Among the qualities claimed for the Springfield stone is its ability to withstand high temperatures. Some years ago the P. P. Mast residence was swept by fire, and while the limestone walls were undamaged, the sandstone, used for trimming, cracked, and had to be replaced. Similar evidence is furnished by the walls of lime kilns in the Mad River Valley, which after 40 years use are still in good condition.

The Springfield stone must be given high rank for building, as its qualities are all favorable. Its color, which is somewhat unusual for a limestone, is attractive, especially to those who admire warmth, and it changes but little with age. The crushing strength is ample, and

it is very durable. The layers occur in varying thicknesses, meeting in this respect almost any demand. Finally it can be secured without objectionable ingredients such as chert and pyrite.

When placed on edge it remains intact to an unusual degree for this position, and hence is well suited for curbings. It can readily be gotten out in large pieces, say five by 10 feet, and makes an excellent walk. For bridge work, the heavier courses are satisfactory.

Covington and Vicinity.—The valley of Stillwater River, from Covington south, shows numerous exposures of Niagara rocks, which have been quarried in a large or small way for many years. The Ruhl quarry at Covington was opened in 1869 and has been a large source of lime and bridge stone, the latter for the Pennsylvania Railroad. Formerly 40 men were employed, but when the place was visited in 1909 the number had diminished to nine. Lime burning was discontinued in the preceding April, and the proprietor expected in the near future to close the quarry. The following section was measured:

	Ft.	In.
Drift	2	--
Niagara limestone.		
Cedarville limestone. Generally split into thin uneven layers. Suitable for lime. Buff color	27	--
Springfield limestone. Thin beds suitable for building stone, the heavier ones for bridge work. Blue-gray color: 8 in., 24, 30, 20, 24, 6	8	6

On the west side of Stillwater River at Covington is the Face quarry, which shows a different bedding from the one just reviewed. At the top lies seven feet of thin uneven beds that probably belong in the Cedarville division. Below this are eight feet of stone in regular layers from five to 14 inches thick. These beds are free from chert and have little or no pyrite. The lower three vary in color, from blue-gray to buff, while those above have the usual buff tint of this stone. It is used for various building purposes, and has found a market at Urbana, Greenville, and other nearby places.

Two miles south of Covington, on the east side of Stillwater River, is the Jackson quarry, where the following section was measured:

	Ft.	In.
Glacial drift	--	6
Niagara limestone.		
Cedarville limestone. Buff or yellow, usually massive. Too soft for crushing. Worthless	6	--
Springfield limestone. Layers not more than 10 inches thick. Uneven surfaces with numerous vertical breaks. Color buff or yellow	7	6
Even beds of buff color, except the lower ones which are partly blue. Some of the thicker ones may split into two. Good building stone: 9 in., 13, 9, 14, 7, 15, 12	6	7
West Union limestone. Color blue with spots of gray. Usually massive, but in three parts, where measurement was made. Hard. Used for crushing only: 3 ft., 1, 4	8	--
Osgood beds.		
Limestone. In layers of from three to 13 inches. Color blue-gray. Used for building, flagging and curbing. Some pyrite. The 12 and 13-inch courses are not good for cutting. The six-inch course, underlying the 12, does not stand freezing: 4 in., 10, 9, 13, 5, 6, 3, 12, 6, 9, 5, 5	7	3
Dark-blue shale	2	--
Layers from six to 12 inches of blue color. Used to a small extent for bridge stone and foundations. Does not withstand action of frost well. Top only seen	10	--
Clinton limestone.		
Reported but not seen.		

The Springfield beds, with the exception of the lower two, have the usual buff color, and are quite free from pyrite or other objectionable impurities. It is softer than the underlying Dayton limestone, but is reported to withstand frost better. For flagging, blocks from 10 to 15 feet in length have been quarried.

The Dayton stone has a fair market owing to its color, but this changes on exposure to various shades of gray.

Ludlow Falls.—In the quarry of the Maxwell Stone Company one-half mile west of this village, is a good exposure of the lower part of the Niagara:

Niagara limestone in the Robinson quarry, two miles south of Covington, Miami County. The lower man stands on top of the Osgood beds and to his back is the massive West Union limestone. The upper man stands on top of the West Union and to his back are the Springfield beds, the layers of which are not well shown. The broken rock under the tree forms the base of the Cedarville division of the Niagara.

	Ft.	In.
Drift	3	--
Niagara limestone.		
Springfield limestone. Thin beds of buff-colored stone. Much broken	2	--
West Union limestone. Massive. Buff color. Too soft for crushing. Used for rip-rap	7	6
Osgood beds.		
Limestone. In layers from three to eight inches. Blue-gray color with considerable pyrite. Used for building stone	6	--
Blue shales	3	6
Dayton limestone. The lower nine feet of the Dayton stone are in layers of from three to eight inches. The color is light blue, and but little iron was observed. It is used for building and as bridge stone. The two 12-inch courses lying above are practically worthless, except for crushing (1 ft. / 1 / 9)	11	--

The principal market for the building stone from this quarry is Dayton, and several places in Indiana. Formerly three additional quarries operated at Ludlow Falls.

Piqua.—This has long been an important quarrying locality but the lower part of the Niagara alone is present. The following section is from the old Clarke quarry, now operated by the Casparis Stone Co.:

	Ft.	In.
Drift	5	--
Niagara limestone.		
Dayton limestone. Layers from two and one-half to four inches in thickness, rather uneven bedded and of buff color	1	7½
Beds of buff or light-blue stone, from two to seven inches in thickness	5	4½
"Miami Valley blue stone." The 17-inch course sometimes splits into a 10 and seven (9 in. / 17)	2	2
Clinton limestone	20	--

The Niagara in this quarry is of good quality. It is free from chert and no pyrite was seen, but its presence was reported from the blue layers. The lower courses, the "Miami Valley blue stone," are most prized, and find a good market for sills, curbing, etc. The new High Street Methodist Episcopal Church at Springfield was built from this quarry, a very good illustration of carrying coals to Newcastle.

The stone has never been extensively used at Piqua, except for foundations, curbings, and trimmings, but this demand is now being replaced with the Bedford and Berea stone. It has had a large market for bridges, and has been shipped extensively by canal to Toledo.

New Paris.—Two quarries in the Niagara limestone along the edge of this village supply rock for lime and crushing. While stone

suitable for building purposes is present, no market for it exists, and hence none is gotten out. The following section was taken in the quarry of Richard Damily:

	Ft.
Drift	9
Niagara limestone.	
Thin, uneven bedded limestone. Buff color. Used for lime	14
Uneven bedded layers. Does not make good lime. Used for crushing	2
Layers from three to eight inches thick. Gray or blue-gray color. Used for lime	3
Building stone. Layers from four to eight inches and fairly even bedded. No pyrite seen	4
Bridge stone. Layers thicker, from 10 to 14 inches. Hard. Color blue-gray	6

In the Reinheimer quarry nearby, 45 feet of limestone were worked, and the company was planning to go 14 feet deeper. Five feet of building stone was found but it was used for crushing. Two 18-inch courses of bridge stone are present. The lower 16 feet contain much chert, one layer perhaps 75 per cent. Much of the stone from this quarry is quite hard, and with the chert, should yield a good product for ballast and road making.

Eaton and Vicinity.—Numerous quarries, large and small, have existed near the town, Eaton, but when the region was visited in 1909 only one was being worked, and that on a very small scale. Building stone has been gotten out for surrounding cities, and towns in both Ohio and Indiana, but the demand grew smaller and smaller until it finally ceased.

The Christman quarry, about three miles northeast of Eaton, had building stone for its one industry, and when that ceased the quarry was closed. Following is a section in this quarry:

	Ft.	In.
Drift	5–15	--
Niagara limestone.		
Hard, blue stone, used for curbings and bridges	--	10
Same as above	--	7
"Soft seven." Used for cut stone, such as sills and caps. Very durable	--	7
"Two fives." Soft, used for steps, caps, etc	--	10
Nine-inch course, sometimes unites with five-inch course above. Used for bridges and heavy work, also for water and milk troughs	--	9
Six-inch course. Soft and of poor quality. Used for underground work	--	6
Blue clay and limestone, worthless	3	--
Soft when quarried, but hardens on exposure. Used for fine work. Two courses each	--	8–10
"Two sixes" like the above, each	--	6

When the Court House at Eaton was built, about 1848, the "hard blue, 10-inch course" was tried, but reported too hard for cutting and in consequence stone from Dayton was used. That from the Christman quarry varies considerably in color. Part is blue-gray and part is buff, the latter being found along large cracks where weathering has been pronounced. Where the buff stone is found in walls it leaves a film of clay on the surface after weathering. Mr. Christman reports that on a knoll, thicker courses are found above those given in the section, one measuring 28 inches, and that from these, stone was used in the Court House at Richmond, Indiana.

The Kautz quarry, on Rocky Run, was the only one in operation in 1909 in the vicinity of Eaton. This is two miles southeast of that town and is of minor importance. The following section was measured:

	Ft.	In.
Drift	3	--
Niagara limestone.		
Shaly limestone	1	6
Light colored, mottled shale	5	--
Layers from two to eight inches. Used for foundations	7	6
Cutting stone. Light gray color, mottled with blue-gray spots (8 in., 9, 8, 10)	2	11

A few hundred feet farther down stream is an old quarry in the Clinton. The rock has the usual bedding, color and crystalline nature. It was formerly used in fireplaces, ovens and chimneys, and hence is called firestone. Manifestly the section given above is of the Osgood beds, and the limestone is at the horizon of the Dayton stone.

Lewisburg.—Near this village, in the northeastern part of Preble County, is a large quarry, which gives an excellent view of the Niagara. A section follows:

	Ft.	In.
Drift	2	10
Niagara limestone.		
Cedarville limestone. Rotten stone. Waste	2	--
Crushed. Not suitable for building	3	--
Springfield limestone. Buff color. Layers from three to 15 inches thick. Durable. Many cracks and joints, hence pieces are small. No pyrite seen. May be quarried in winter	8	--
West Union limestone. Used for crushing, may consist of one bed, or split into several	4	6

	Ft.	In.
Osgood beds.		
Limestone. Used for building and bridge work. May be gotten in almost any size blocks. Blue-gray color, sometimes mottled with spots of darker blue. The 10-inch course is suitable for underground work only. Cannot be quarried in winter. Pyrite found: 6 in., 4, 5, 8, 3, 7, 7, 13, 8, 5, 15, 10, 20, 8	9	11
Blue clay	3	--
Blue-gray limestone. Top four feet only seen	10	--
Clinton limestone. Reported but not seen	14	--

This quarry is very old and probably dates from near the time of the country's settlement. From about 1887 railroad connections have been had, and of course this greatly extended the market. Twelve hundred cars of building stone were reported shipped in 1901. A year later a notable decline set in, and in 1908 the output was only 200 cars. Now the one industry is crushed stone, and this finds a market along the Cincinnati & Northern Railroad from Cincinnati to Bryan, or in other words across the State. Manifestly this quarry contains a large quantity of good building stone in both the Springfield and Dayton horizons.

Hillsboro.—This has long been an important center in the stone industry, though in recent years but little work has been done. Following is a section in the Beecher quarry which was opened about 65 years ago in an endeavor to tunnel the hill for railroad purposes:

	Ft.	In.
Drift	5	--
Niagara limestone.		
Massive limestone of buff color. Contains many fossils	15	--
Shaly limestone	1	6
Usually massive, may split into 3 or more uneven beds. Some chert present	2	6
Beds fairly even, but limestone appears of poor quality: 5 in., 7, 4, 6, 8	2	6
Shaly limestone	--	5
Limestone	2	--
Limestone	2	6
Shaly limestone	--	6
Massive limestone	3	4
Limestone	1	5
Shaly parting	--	1
Massive limestone with large pieces of chert	9	--

The stone has not been used in a large way for buildings except for foundations. The Episcopal Church at Hillsboro, erected about 1850, is of stone from the local quarries, but the one fine structure of it is the Beecher residence, built in 1883. The body of the walls is of limestone, and trimmed with Buena Vista sandstone and red bricks, the latter around the windows and in the chimneys.

The Niagara Limestone in Northern Ohio

As has already been stated, the Niagara forms the surface rocks over hundreds of square miles in Northern Ohio, including parts of Marion, Hardin, Wyandot, Hancock, Seneca, Sandusky, Wood and Ottawa counties. The divisions in Southern Ohio have not been recognized here and the stone resembles that of the Cedarville division. It is often massive, but sometimes shells near the top, has a gray, or blue-gray color, is highly fossiliferous and often full of holes. Nowhere in this area has it been worked regularly as a building stone, though occasionally enough has been quarried for a foundation to a building or abutments for a bridge. Nearly always it lacks the regularity of bed necessary for architectural purposes, and besides the general appearance is unfavorable.

THE MONROE LIMESTONE

The Monroe limestone, or as it was formerly known, the Lower Helderberg or Waterlime, forms the rock floor of much of Western Ohio. Its area is at least equal to that of the Niagara and it measures nearly 300 feet in thickness, where the entire formation is present. Orton describes it "as, in the main, a strong, compact, magnesium limestone, poor, as a rule, in fossils, and often altogether destitute of them for considerable areas, microscopic forms having been excepted. It is for the most part, drab or brown in color; but occasionally it becomes very light colored, and again it is found dark blue in color. Throughout much of its extent it is brecciated, and the beds seem to have been broken into either small or large angular fragments after their hardening, and then to have been recemented without further disturbance. In addition to this, it contains an immense amount of true conglomerate, the pebbles, many of which are boulders rather than pebbles, being all derived from the rocks of the same general age, but frequently differing in color from the matrix. The most striking exhibitions of this phase are found in Lucas County * * *. A rude concretionary structure is also quite distinctive of the beds of this age. The Waterlime of Ohio everywhere contains petroleum in small quantity, which is shown by the odor of freshly broken surfaces * * *. At some points it carries considerable asphalt, dis-

tributed through the rocks in shot-like grains, or else in sheets and films. Thin streaks of carbonaceous matter traversing the rock parallel to its bed planes are one of the constant marks of the stratum in Ohio. It is generally thin and even in its bedding, but in some localities it contains massive beds. In Southern Ohio it has a maximum thickness of one hundred feet, and here it reaches its highest quality in all respects."[1]

In Lucas and Wood counties it contains an imbedded layer of sandstone that has been extensively worked for glass making. A similar stratum, which has been found in deep wells in Ashtabula County, yields petroleum and natural gas, the latter in large quantity. This bed of sandstone has been reported in other deep wells in Northern Ohio.

The composition of the Monroe limestone is well known. It is dolomitic, as is demonstrated by the following analyses:

Rucker's Quarry, Greenfield, Highland County[2]

Calcium carbonate	53.67
Magnesium carbonate	42.42
Alumina and iron	1.30
Silicates of lime and magnesia	1.44
Silica	1.00
	99.83

Limestone, Ottawa County[3]

Calcium carbonate	54.12
Magnesium carbonate	44.79
Alumina and oxide of iron	0.25
Silica	0.29
	99.45

As a building stone, the Monroe limestone is of little importance, and is worked for that purpose in one locality only, Greenfield, Highland County. There the stone is at its best; in fact it is the only place in Ohio where the formation has ever been extensively quarried for building stone. Before describing it, a section from the Rucker quarry will be given:

[1] Orton, Edward, Geol. Surv. of Ohio, Vol. VII, pp. 14-18.
[2] Wormley, T. G., Geol. Surv. of Ohio, Rept. of Progress for 1870, p. 287.
[3] Peppel, S. V., Geol. Surv. of Ohio, Fourth Ser., Bull. 4, p. 108.

A.—Presbyterian Church at Greenfield, built of Monroe (Greenfield) limestone and trimmed with Bedford. Photograph by B. G. Watson.

B.—View of the Monroe limestone in the Rucker quarry at Greenfield. Note the even layers. Photograph by C. W. Napper.

		Ft.	In.
Drift		6–18	--
Monroe limestone.			
Thin, uneven beds, much broken by cracks. Buff color. Used for crushing and lime		6	--
Massive. Used for crushing and lime		5	--
Building stone, buff color, fine grained, rather brittle, with many cracks, and hence cannot be gotten out in large blocks. Gets a trifle lighter on exposure	5 in. 8½ 1½ 12 7 22 8 7 12	6	11
Thin layers used for crushing		13	--
Building stone. Dark gray color, changing to a lighter shade on exposure. Some of the thinner courses, shaly. Most of the thicker beds may split into two layers	3 in. 4 6 6 3½ 16 10 4½ 7½ 9½ 9½ 9½ 13½	8	6½
Flint layer. Used for crushing		--	4
Building and dimension stone. Gray color.	3½ in. 7 Used for steps. 6 Used for caps, sills and range work. 12 May be split and used for curbing. 6, 6 Best in quarry for curbing. 2 4½, 9, 13½, 6, 7 Used for bridges, curbing, range work and general building purposes. 5, 9, 13½, 8, 28, 7½, 7½ The 28-inch course and some others contain ZnS. Used for general building purposes.	13	3
Massive limestone.	Unmeasured.		

The striking feature of the stone as shown in this quarry is its evenness of bed, and so marked is this that it sometimes looks as if

it had been planed. On this account it has had a large market for sidewalks, the stone requiring no surface dressing at all.

The massive limestone at the base of the quarry and the overlying 22 feet have a dark-gray color with a profusion of the black lines already referred to by Dr. Orton. Usually these are parallel and slightly wavy, and probably represent surfaces of weakness.

Overlying these dark-gray courses are beds of buff, usually quite free from dark lines, fine in grain and even in texture. The numerous cracks cut this stone in small blocks, while the underlying gray courses may be gotten out in almost any size. The stone of this formation is very much less crystalline than most of those previously discussed in this bulletin. In fact it frequently appears non-crystalline to the naked eye, resembling in this respect the buff stone of the Springfield horizon.

The five-foot massive course near the top of the quarry often contains a profusion of well rounded limestone pebbles, usually about an inch in diameter. These resulted from wave action when the locality was at or near a shore line. Large "hard heads" are common. These are more or less oval or spherical in shape and may reach 30 or even 40 feet in cross section. They are massive, that is, do not separate into horizontal layers, but sometimes they split along their surfaces in concretionary fashion. Again they form compact masses, and then are hard to prepare for the crusher or kilns. The building stone courses often contain concretionary-like bodies that are in places pear shaped. They may have the constitution of the enclosing rock, or may be crumbly in their interior. Naturally they are objectionable.

The principal market for the stone has been Cincinnati, but it has been shipped as far as Parkersburg, Marietta and Toledo. The market has been for building stone, flagging and bridge work. Later it was tried for street paving, but the results were not satisfactory. Neither is it well adapted for curbing, the rock shelling under the action of frost.

When the Rucker quarry at Greenfield was opened is not known, but it was purchased by the present owner from the Devoss Brothers in 1866. Before that time the rock was transported by wagons, but the new proprietor at once began shipping by rail, and in 1878 had a switch built to the quarry. For many years lime was burnt on a large scale in six kilns, but in later years only one has been operated, and that irregularly. With the decline in the market for building stone, a crusher was started, and now the principal product of the quarry is crushed stone.

About one and one-half miles south of Greenfield, on the west bank of Paint Creek, is the small quarry of C. B. Fleming. A ledge of perhaps 20 feet is worked, and all except the lower three feet is of the buff variety. The stone is much broken by cracks, some of which are four

inches wide and filled with clay. The lower courses, and occasionally the upper ones, have numerous geode-like pieces of quartz. The product is building stone and that for the local market only. The stone has been worked to a small extent in one or two other places near Greenfield.

Near the village Highland, about 12 miles west of Greenfield, are several small quarries in an island of the Monroe limestone. In the quarry of Daniel Sharp approximately 30 feet of rock are shown. The top 12 feet are much broken, but farther down the beds are more continuous. The beds are usually less than five inches in thickness, except in the lower 10 feet where they reach a maximum of 24. Even there, however, most of the layers are less than one foot. The two-foot course often shows about one-half inch of black flint a few inches above its base. The stone has the general characters shown in the Greenfield quarry. The Hixon quarry adjoins the Sharp, and when visited the stone was being crushed in a portable crusher. Lime was formerly burnt on a small scale.

The Monroe limestone, as has already been stated, outcrops over thousands of square miles in Northwestern Ohio. It is extensively quarried at several places, and a description of the stone in a few of these will suffice to show its characteristics.

Dunkirk.—This town, in the northern part of Hardin County, is the site of one of the largest quarries in Ohio. Probably 40 acres have been worked over (1910) to a depth of 35 feet. The stone, which is used for crushing only, consists of thin layers that are usually under six inches in thickness. Occasionally, however, the stone forms irregular shaped pieces that are tough, and show no tendency to split into layers. Considerable shale is interbedded with the limestone. The surfaces of the layers are not parallel, and so the pieces vary much in shape. Innumerable cracks break the rock, so that after having been shot it is loaded with a steam shovel. The stone which has a buff color darkens below, and is notably lighter than the shale. The dark lines, due to organic matter, are commonly present. No flint or chert was noted but pyrite was occasionally found. Not a fossil was seen. The one use for this stone is crushing, the Pennsylvania Railroad using it for ballast.

Middle Point.—This village is the site of another great quarry in the Monroe, between 40 and 50 acres having been worked over to a depth of 25 feet. The stone is buff near the surface but a little darker below. It is slightly more evenly bedded than is usual in this formation, but not well adapted to masonry. One layer of 18 inches was noted near the base of the quarry, but the cracks break the rock into small pieces, so that after shooting, it is loaded with a steam shovel. The rock is usually not only porous but full of holes, suggesting in that respect the Cedarville limestone.

To a small extent stone from this quarry is used for flux, and the company hopes to increase this market. Occasionally farmers pick out pieces for foundations for buildings and the stone does fairly well for that purpose, especially for underground work.

North Baltimore. — Many acres of the Monroe have been worked at this village to a depth of about 12 feet. At the surface the rock has a buff color, but below it changes to blue, and this to buff after a few years exposure. The rock may be described as a shaly limestone, few courses measuring as much as four inches. In other respects the stone resembles that at Middle Point and Dunkirk. It is crushed and used for ballast on railroads.

Tiffin. — In the quarry of the Tiffin Lime & Stone Company both the Monroe and Niagara limestones are quarried. The former occurs in thin beds, rarely measuring 10 inches, and the surfaces are sometimes nearly parallel. As usual cracks are very common near the outcrop. It has a drab color, is free from chert and no pyrite was seen.

The thicker courses are occasionally used for building stone, but only where cheap construction is permitted. Other uses are for lime and crushed stone.

These brief descriptions might be duplicated over and over again from the Monroe of Northwestern Ohio, but sufficient has been said to show that the formation has very little value as building stone. Its thinness and unevenness of bed alone prevent its use for that purpose. Besides it is unattractive, the color and texture giving an unpleasant effect.

THE DEVONIAN LIMESTONES AS SOURCES OF BUILDING STONE

The Devonian limestones of Ohio occur in three distinct districts, remnants of an extended area that seems to have covered much of the northwestern quarter of the State. In order of their size these are, (1) the Central district, (2) the Northwestern district, and (3) the Bellefontaine district.

The Central district forms a belt from Pickaway County on the south to Kelleys Island on the north, a distance of about 140 miles. It is narrowest near Delaware, measuring approximately five miles, and widest a short distance north of Bucyrus where it is about 17 miles. The average of the entire belt is about the same as that of the two members just given.

The Northwestern district is considerably smaller than the Central. It extends as a broad belt, curving from Lucas County southwest through Wood, Henry, Defiance and Paulding counties. Westward it continues into Indiana, and northward into Michigan. Its width ranges from three to 13 miles.

The third district is an irregular oval patch in Logan County, with a much smaller one to the south in Champaign, and possibly one to the north in Hardin. These are to be looked upon as outliers which formerly extended east and north, uniting with the Central and Northwestern districts. They are simply remnants that have escaped erosion during the long interval that has elapsed since the rocks under consideration were formed.

The Devonian limestones of Ohio are divisible into two formations, a lower one known as the Columbus, and a higher one called the Delaware. Both are found in the Central and Northwestern districts, though in the latter the Delaware formation cannot be separated from the Olentangy. Stauffer applies the name Traverse to these two in that section of our State.[1]

The Columbus and Delaware limestones in Central Ohio can usually be distinguished without recourse to the contained fauna. The Columbus generally has a gray or buff color, and in the lower part is thick bedded; while the Delaware is dark blue, quite even bedded, and the layers commonly less than one foot thick. Near Columbus, in fact, the Delaware is represented by shales, making the distinction very easy. Farther north the two formations are more alike, and at Sandusky can be separated only by the contained fossils.

In thickness these formations vary considerably from place to place. At Columbus the maximum thickness of the Columbus limestone, according to Stauffer, is 105 feet; at Sandusky 61 feet; near Silica (Lucas County) about 50 feet; near East Liberty (Logan County) perhaps 100 feet with a chance for larger error since the rocks included in this measurement may in part belong to the Delaware.

For the Delaware limestone, Stauffer gives the following measurements—at Sandusky 70 feet; at Delaware 30½ feet, without reaching the base of the formation; near Silica about 56 feet, but Stauffer thinks this includes the Delaware limestone and Olentangy shales, the two forming there a single formation.

THE COLUMBUS LIMESTONE

It is in order at this stage to describe in more detail the two divisions of the Devonian limestone, and then to review the principal quarries in these rocks. Naturally, the lower or Columbus beds will be considered first.

As has already been stated these beds are found in each of the three districts where the Devonian limestones occur. In the Central they extend continuously from Pickaway County north to Kelleys Island, and are extensively worked at numerous places, as will be pointed

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 10, p. 178.

out later. From their thickness and area of outcrop it appears that the quantity of this formation is greatly in excess of the overlying Delaware, and is in fact practically inexhaustible.

The Columbus limestone may be classed as fairly even bedded, the layers of which vary from a few inches to six feet or more in thickness. Usually the thinner layers are near the top and the massive ones below. In fact the heaviest courses are always near the base. These points will be emphasized in sections of quarries on later pages. The rocks are broken by numerous, more or less, vertical cracks, and in places these occur in two sets nearly at right angles to each other. Naturally these bedding planes and cracks aid the quarryman.

The rock is generally crystalline, and sometimes so much so that, in the rough, it resembles marble. It does not, however, take a polish comparable to that stone. Its crushing strength is adequate for the largest structure, as will be shown later. The stone is moderately hard, and fairly tough, but does not carve well. Fossils are plentiful.

In composition the rock may be described as a calcareous limestone, though magnesium is always present, and sometimes in such quantity as to suggest a dolomite. The higher layers, as a rule, are richest in $CaCO_3$, and lowest in $MgCO_3$. Below, the $CaCO_3$ decreases and the $MgCO_3$ becomes more abundant. These points are well shown by the following analyses of samples taken at Marble Cliff near Columbus. The first is of the layer known as the "Gray-rock," near the top of the formation, and the second of the "Six-foot-six," near the base.

Composition of "Gray-rock."

	Per cent.
Calcium carbonate	96.51
Magnesium carbonate	1.43
Silica	1.10
Iron and alumina	.70
Phosphorus	.04

Composition of "Six-foot-six."

Calcium carbonate	80.900
Magnesium carbonate	16.070
Silica	2.000
Iron and alumina	1.100
Phosphorus	.016

That the formation varies in composition, areally as well as vertically, is shown by comparing the above with Marion.[1]

[1]Lord, N. W., quoted in Geol. Surv., Ohio, Fourth Ser., Bull. 4, p. 93.

	Top of Columbus limestone	Middle and lower Columbus limestone
Calcium carbonate	79.01	66.02
Magnesium carbonate	16.85	33.10
Silica	3.50	1.60
Alumina and iron oxide	0.50	0.24

On Kelleys Island in Lake Erie the stone has the following composition.[1]

	1	2	3	4
Calcium carbonate	97.28	87.10	89.16	77.22
Magnesium carbonate	2.00	10.96	9.48	20.19
Alumina and iron oxide	0.27	0.15	0.20	0.14
Siliceous matter	0.85	1.49	1.05	1.65
	100.40	99.70	99.89	99.20

These four analyses are of different vertical parts of the same quarry. The third is of beds that have been used most commonly for building stone. The analyses demonstrate nicely the varying proportions of carbonate of calcium and magnesium from the top to the bottom of the quarry.

Chert is the one great impurity in the rock. It is not evenly distributed but is commonly restricted to certain layers, and these, of course, should be rejected in quarrying building stone. Alumina and iron oxide are always present, but the quantity is so small that it can hardly be rated objectionable. Occasionally pyrite is found, but it is so uncommon that it may be neglected. In only one place were these yellow crystals found numerous, and that was at Sandusky, and in the part of the ledge that is never used for building stone.

The color of the Columbus limestone ranges from gray through buff to blue, the latter being common at Sandusky. Probably shades of gray are the most frequent. On weathering the color usually darkens, and the stone from the vicinity of Columbus at least becomes slightly mottled with darker and lighter shades of gray. Viewed from the standpoint of durability the Columbus limestone must be given an excellent rating. It shows little disposition to scale or crumble, and withstands the trying Ohio climate as well as any stone, with the exception of the best granite. Like all limestones it is soluble, but the degree of this varies from layer to layer, and even in adjacent parts of the same bed. As a result of this the surface roughens on weathering, becoming marked by irregular projections and depressions. Good examples may be seen on the walls of the State House.

And yet, notwithstanding these good qualities, the stone has not proven popular for building, except for foundations, sills and caps.

[1]Lord, N. W., Geol. Surv. of Ohio, Vol. VI, p. 753.

For some reason, not easy to state, it is not pleasing to the eye. To this statement massive structures like the State House should be excepted, and perhaps smaller ones, such as residences, where the face of the stone is left in the rough. There seems to be a growing demand for the latter style and it may lead to a good market for this stone.

THE DELAWARE LIMESTONE

The area of this formation is smaller than that of the Columbus and it is less extensively worked. Near Columbus, as has already been stated, it is represented by shales, or shaly limestone, but farther north at Delaware and vicinity it forms an even-bedded dark-blue limestone. The latter two characters—color and evenness of bed—are almost characteristic. Commonly the layers are less than eight inches in thickness, and those 12 inches or more are not numerous, and are usually restricted to the lower part of the formation. At present the principal quarries are at Delaware, Marion, Bloomville and Sandusky and vicinity.

Like the Columbus limestone, the Delaware has well-marked bedding planes, and numerous, nearly vertical, cracks and joints. These characters, with the thinness of bed, makes the stone easy to quarry. The stone is fine-grained and compact. It is harder than the Columbus limestone, and like that has a high crushing strength. It does not carve well.

At Delaware the stone has the following composition:[1]

	Top 5½ ft. Shelly.	Lower 24 ft.
Calcium carbonate	91.31	69.80
Magnesium carbonate	5.12	17.21
Silica	3.02	10.36
Alumina	0.95	2.71
Oxide of iron	0.25	0.05

As in the Columbus limestone the leading impurity is chert, but here again this material is usually restricted to certain layers and not scattered promiscuously through the rock. Iron and alumina are always present but never in large proportions. Pyrite, while occasionally seen, is never so abundant as to mar the stone.

As has already been stated the color of the stone is dark blue, but near the surface this weathers to gray or yellow. The Sandusky stone changes on exposure to a light gray that sometimes resembles marble when viewed from a distance. While the color of the Delaware stone in the unweathered variety is attractive, it is not always so after

[1]Orton, Edward, Jr., and Peppel, S. V., Geol. Surv., Ohio, Fourth Ser., Bull. 4, p. 61.

long exposure, the resulting gray, buff and yellow tints often being displeasing. Especially is this true of the stone from the type locality, Delaware.

From the standpoint of durability the Delaware limestone ranks well, and especially is this true of that from Sandusky. The stone from Delaware, however, scales and appears to be less durable. All in all, the Delaware limestone ranks as an excellent building stone. It is easy to quarry, occurs in unusually even beds, is free from objectionable impurities, is strong and durable, and generally pleasing to the eye.

Having now reviewed the characteristics of the Devonian limestones from the standpoint of building stone, it will be in order to describe the product of the leading quarries. In this we will begin with the Central district, starting at the south.

The Central District

Columbus.—As has been stated, the Delaware formation here consists entirely of shales, or shaly limestone, and so this discussion will be restricted to the Columbus limestone.

Quarrying this rock dates perhaps from the time of settlement of the city. As the population grew, and more substantial structures were erected, the market for stone increased. About 20 years ago demand for the stone became large for purposes other than building, and especially so for ballast and flux. This led to a great extension in quarrying and the industry has become one of the largest in Central Ohio.

In early days the principal quarries were located just north of the Central Hospital grounds, but during the past 30 years the industry has moved up the Scioto River, and now extends from the vicinity of Marble Cliff to near the storage dam. Restricting our attention to building stone, attention is called to figure 3, which gives a section from top to bottom of the quarry near Marble Cliff. As will be noted each bed has a name, some being simply that of the thickness, while others are from some quality of the stone, such as "rough rock," "blue rock," "top hackle," etc. The thickness of the beds varies from place to place, hence the section given cannot be duplicated in detail in other places.

Practically all of the formation at this locality can be employed for building stone, but the thinner courses are most used, except for massive structures, such as the State House, where heavier beds are desirable. More specifically the best stone for our purpose lies between the "Top courses" and the "Two-foot Course."

The quality of the Columbus limestone in this locality meets the best standard for the formation, except perhaps that at Sandusky. Its crystalline nature early caught the eye of quarrymen who seem to

have thought that certain courses in it resembled marble, hence the name Marble Cliff. As a foundation stone it is in every respect excellent, and any course of sufficient thickness may be used. For sills, caps and similar purposes it is also of high grade, as has been proven in hundreds of Columbus buildings. For the walls of residences and business structures it has all requisites, except that of pleasure to the eye. For massive buildings nothing seems to be lacking, as is well shown in the State House and Judiciary Building. The stone for the former was gotten in the State quarries near the Central Hospital, the heavier courses being used. The columns were supplied by the five and one-half-foot course, which at that time formed the base of the quarry, while the steps came in large part from the "Sheepskin."[1] This structure was built about 65 years ago, and demonstrates how well the rock withstands our trying climate. The Judiciary Building was erected about 20 years ago from stone obtained in the old Taylor & Bell quarry near Marble Cliff. Where a rough exterior is sought the stone is excellent, as is shown by the church at the corner of Neil and West Sixth Avenues, and in residences at Arlington and nearby villages.

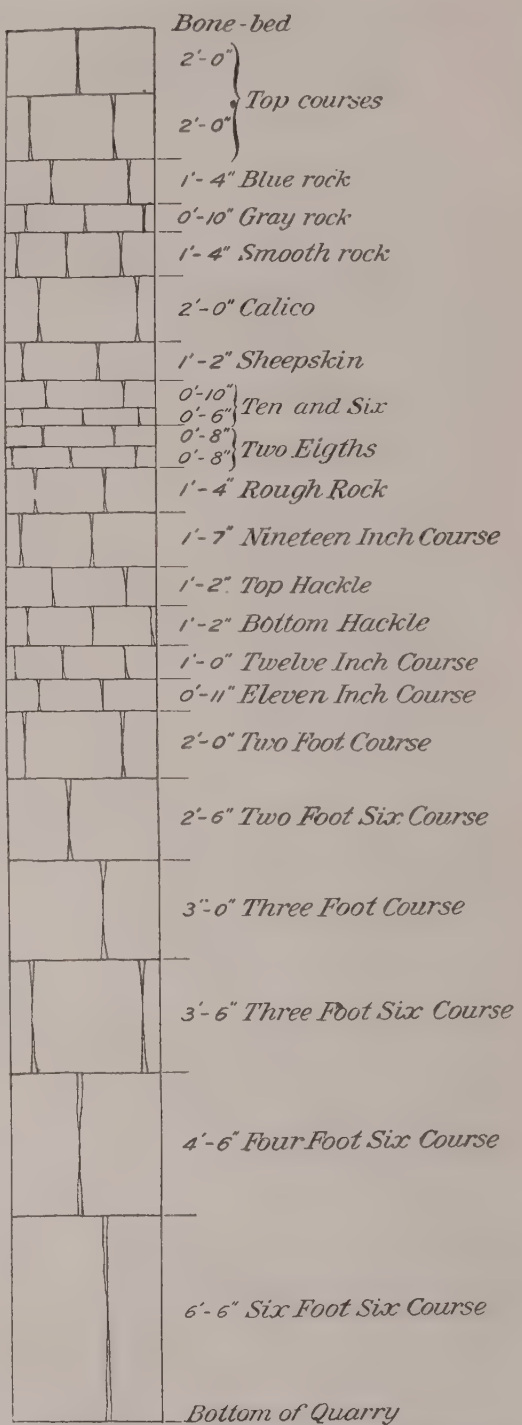


Fig.—3.—Section of Columbus limestone at Marble Cliff.

For steps the stone is first class. It can readily be gotten in suitable size, looks well and is durable. For this purpose it

[1]Orton, Edward, Geol. Surv. of Ohio, Vol. III, pp. 609, 612.

A.—State House, built of Columbus limestone. Photograph by J. E. Hyde.

B.—Devonian limestone in Wagner quarry No. 1, near Sandusky. Layers usually less than 10 inches thick.

is superior to the more popular Bedford limestone of Indiana. It does very well also for sidewalks where heavy usage is demanded, and for curbings.

Delaware.—This is the location of the first important quarry north of those at Columbus, and the name of the city has been given to the formation. While the stone is reported to have been worked in a small way as far south as the Powell Road, nine miles from Delaware, the only quarry of importance is at the latter place. As early perhaps as 1850 the limestone was worked for building stone and lime in the little valley just north of the Hocking Valley station. Soon the burning of lime was discontinued, but the building stone industry grew. At first the market was local, but with a railroad for transportation the field widened, extending from Columbus to Toledo and Springfield. In more recent years, with the growth of the cement industry, the market for building stone has fallen off, so that at present the main use of the stone is crushing for ballast, highways and concrete.

Following is a section in the old Campbell quarry just east of the Hocking Valley tracks:

Delaware limestone.	Ft.	In.
Shaly layers, not suitable for building stone	6–8	--
At least 18 layers, none more than 15 inches thick, even-bedded	9	--
Thick or thin, even-bedded courses, well suited for building stone: 1 6; 1 0; 1 3; 0 6; 1 0; 0 7; 1 3; 2 0; 1 3	10	4

This gives a thickness of about 20 feet, excluding the shaly beds at the summit. The stone is very even-bedded, fine-grained, and usually has a dull-blue color, but occasionally a fresh surface appears buff. The surfaces sometimes are shaly, but this material readily yields to the stone mason's tools. Occasionally lighter colored spots are found, apparently of a cherty nature, and sometimes chert itself is common. Where found, however, it is usually restricted to certain beds, and these could be rejected without difficulty. It is notably less crystalline than the Columbus limestone, and more compact. Every fresh surface gives a marked odor of petroleum. The quarry is no longer worked, having been practically abandoned in 1909 when the White Sulphur Stone Company got possession of it. Previous to that time building stone had been the chief product of the quarry.

Directly opposite this quarry, and on the west side of the railroad, is another one, owned by Frank L. Campbell, but at present leased to the White Sulphur Stone Company, by whom it is operated. When the place was visited in 1912 a ledge of 24 feet was being worked, but the company was considering going 15 feet deeper. The general character of the stone here is similar to that in the preceding quarry. It is notably more blue in color, doubtless because of its fresher surface. One ledge in particular is deserving of special mention. It lies about two and one-half feet above the base of the quarry and is 22 inches thick. It shows no sign of splitting into thinner layers, is fine-grained and compact, free from chert or pyrite and should make an excellent stone for foundations, or for any purpose where a heavy ledge is required.

The available supply of Delaware limestone in this vicinity is not great. To the east and south, quarrying is prevented by the city, while northward the drift is too deep. Though the market formerly extended to other cities, Delaware has been the leading place, and naturally that city affords a good opportunity to study the building stone after years of exposure. Among the earliest structures erected from it are the Campbell residence (now the University Art Hall), St. Peters Episcopal Church, Asbury Methodist Episcopal Church, and a residence at 126 Winter Street. Examination of these walls shows colors ranging from gray, through buff to yellow, and giving on the whole an unpleasant effect. Further, the stone often develops a shaly structure, and sometimes scales off in directions other than those of the bedding planes. Perhaps these conditions result in part from poor stone having been used. Similar results may be found in the basement of the Chemical laboratory on the University campus. Merrick Hall, on the same grounds, has a basement of fairly thick and even courses, giving a pleasing effect, but the rest of the building, except the trimmings, are of thin uneven layers. The basement of the new gymnasium shows the stone at its best, though perhaps the dark mortar is not an improvement. That the stone is not considered first-class locally, except for foundations, is shown in Gray Chapel, which is of Berea, and in the Slocum Library which is of Bedford.

White Sulphur.—On or near the banks of the Scioto River, close to the hamlet of White Sulphur, about five miles a little south of west of Delaware, are two quarries. That on the east side of the river shows a ledge of 34 feet, probably all of which is the Columbus limestone. It has a gray color, is somewhat uneven bedded and quite crystalline. The layers vary from a few inches to two feet in thickness, those from 10 to 12 inches being common. No building stone is quarried but it might yield a good grade. At present the stone is burned for lime, both the hydrated and ordinary grades being made on a large scale. The market includes parts of Ohio, Pennsylvania, Indiana and Illinois.

The quarry on the west bank of the Scioto produces crushed stone only, which finds a local market, and is shipped by the Big Four Railroad. The higher layers are thin and much broken, but those below are thicker, one measuring about four feet. The beds are somewhat uneven, and this, with the dark color, renders it unsatisfactory as a building stone, except for foundations and underground work.

Owen Station.—This place, in the southern part of Marion County, has long been the scene of extensive quarrying. As early perhaps as 1850 lime was burned, and since 1910 the hydrated variety has been produced. The following section of the rocks is from Dr. C. R. Stauffer's bulletin:[1]

	Ft.	In.
Delaware limestone.		
Rather thin layers of blue limestone, with much bluish white chert	5	--
Massive and thin layers of blue limestone, with some chert, and usually shale partings	5	4
Soft, shaly, blue limestone	1	--
Thick, even-bedded, blue limestone, with shale and cherty partings	3	9
Massive, blue limestone in even beds	3	6
Columbus limestone.		
Massive, bluish-gray limestone	10	--
Massive, bluish-gray limestone in even beds	18	--
Massive, bluish-gray limestone	2	6
Fine-grained, gray limestone, at places showing a bluish cast	14	6

As the section shows this quarry is in both divisions of the Devonian limestone. The upper or Delaware beds are not as regular as in the type locality, but they are still used to a small extent for building purposes. The lower or Columbus beds are somewhat uneven-bedded, and are not used except for lime and crushed stone.

Marion.—This is one of the most important quarrying centers in the State. Just north of the city limits and along the Hocking and Pennsylvania railroads is a low knoll about 25 feet in height, the site of two quarries. On the western side of this elevation, in the quarry of the John Evans Lime & Stone Co., the following section was measured:

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 10, p. 93.

	Ft.	In.
Delaware limestone.		
Buff stone, with much chert, thin and uneven-bedded. Used for flux, the cherty pieces for crushing	14	--
Building stone, splitting into four or five layers	2	--
Range or dimension stone	--	11
Cherty layer	--	5
Building stone	1	--
Building stone of poor quality. Used for foundations	1	--
Building stone, used for range work	1	6
Cherty bed, formerly used for bridge work. Now used for crushing	2	--
Chert and shale. Crushed	--	6
Bridge stone	1	--
Bridge stone	--	7
Bridge stone	1	7
Bridge stone	1	--
Building stone, used for range work	--	6
Bridge stone	1	11
Columbus limestone.		
Layers from two to 10 inches. May be used for building, flux or crushing	4	--
Used for flux or lime. Too uneven-bedded for building stone	10	--
Much chert, used only for crushing	4	--
Divisible into two or more beds. Might be used for bridge stone. Now used for flux	5	--
Might be used for building, but now for lime and flux	5	6
Excellent for lime. Employed also for flux, and might be a source of building stone	5	--

The Columbus limestone, in general resembles that at the type locality. The lower ten feet of the section are gray, and the remaining ones usually buff. Often the gray courses are much broken, and this in a way diminishes their value as building stone. The buff courses are better adapted to this purpose, but they are over-shadowed by the more regular layers of the Delaware division. The latter resembles the stone at Delaware in its bedding, texture and dark-blue color. As the section shows, the top 14 feet are buff, doubtless a result of centuries of weathering. The stone has been quarried for several decades and still enjoys a good market. When the Evans quarry was visited in June, 1912, three carloads of building stone were being shipped daily to Columbus. Naturally Marion has afforded a good market. Probably the best advertisement is furnished by the Marion County Bank Building, of blue stone with red mortar, and trimmed with red sandstone. It was erected about 1890, and is very little or none the worse for wear.

The second quarry on the knoll is that of the Ohio & Western Lime Company, and the section given on a preceding page may be

readily duplicated in this. The best parts of the Delaware formation are worked for building stone, and the quantity produced is considerable. Common and hydrated lime are made on a large scale, and much stone is shipped as flux and crushed for ballast, road building and concrete.

About a mile north of these works are two or three small quarries, in one of which lime is burned, and in the others stone crushed. Generally the bedding planes are not parallel, and the prospect for good building stone, other than foundation, is not favorable.

Spore.—About six miles northwest of Bucyrus, near the station Spore, is the quarry of the Brokensword Stone Company. Dr. C. R. Stauffer, who has made a careful study of the rocks, gives the following section:[1]

	Ft.	In.
Delaware limestone.		
Hard, blue limestone	1	8
Soft, blue, shaly limestone	--	3
Thin bedded, and rather massive layers of very hard, blue limestone	2	6
Soft, blue, shaly parting	--	1
Hard, blue limestone, in layers from three to six inches thick	3	8
More or less bluish-gray limestone	--	10
Columbus limestone.		
Thin bedded, blue limestone	2	8
Gray limestone, rather massive, but splitting into thin layers	10	8
Rather massive, gray limestone	4	--
Compact, very hard, bluish limestone, with some chert	4	--
Crystalline, gray limestone, with much petroleum	3	--

Building stone was formerly quarried in a small way at this place, but the practice has been discontinued. The quality of the stone is not equal to the best for this purpose, being somewhat uneven-bedded, and the layers often too thin. Crushed stone is the one product at the present time, though a little is occasionally marketed for flux and agricultural purposes.

Bloomville.—This village is in the southeast quarter of Seneca County, and has long been the site of extensive quarrying. Formerly lime was burned on a small scale but this has been discontinued. Crushed stone has always been the chief product, though some building stone has been quarried. The following section was measured in the France quarry, one and one-half miles east of the village:

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 10, p. 109.

	Ft.	In.
Delaware limestone.		
Thin, uneven layers of buff limestone, with much light-colored chert. Used for crushing	26	--
Good quality, but too massive for building stone	1	6
Same as above	1	6
Building stone courses	--	5
	--	6
	--	8
	--	3–4
	--	5–6
Thin, uneven-bedded courses, not suitable for building stone	3	2
Columbus limestone.		
Too massive for building	1	10
Building stone	1	--
	--	9
	--	6

As the section shows a large part cannot be used as building stone, though some of excellent quality occurs in two thick layers. This would serve admirably for bridge work. The upper 26 feet of the Delaware formation have a buff color, doubtless due to the long weathering of the blue. The bedding planes are not parallel, and this, with the thin layers and abundant chert, render the stone fit only for crushing. The best building stone in the quarry is supplied by the five thin beds that lie beneath the two 18-inch courses. Of these the five, six and eight inch courses dress a little easier, and hence are sought for dressed stone. As a rule the rock at this place does not possess the dark-blue color of the Delaware stone, and may well be described as blue-gray. The top three inches of the eight-inch course has a lighter color than the lower part. The lighter tint is doubtless a result of oxidation, and suggests that the bed has been a surface for underground water. These layers are free from chert and pyrite, and seem to yield a building stone of excellent quality. The lighter tint will probably result in less change in color on exposure, and this should prove an advantage.

A good market for the stone is had at Toledo, Tiffin, Mansfield, Bucyrus, Alliance, Columbus and other places. At present it is being used in the construction of the new buildings for Heidelberg University at Tiffin.

Bellevue.—This city has been the location of extensive quarrying for many years. Probably work began when the locality was first settled, for the stone lies near the surface, and the pioneers would be quick to appreciate its advantages for lime and building purposes. In the quarry of the Bellevue Stone Company, near the western edge of the city, the following section was measured:

	Ft.
Columbus limestone.	
Gray to buff color, rather thin bedded, with uneven surfaces, broken and often containing much chert	20
Gray stone, thin or thick bedded	5
Monroe limestone.	
Massive layers of two feet or more in thickness, banded, gray	17

From the above section it is apparent that this quarry does not yield good building stone. Much dressing would be required and this adds to the expense. Moreover, the general appearance of the stone in unattractive. Nevertheless, the top of the Monroe is occasionally worked in a very small way for this purpose. Several stone residences may be seen in Bellevue that were built from the local quarries, and the walls are in good condition after 50 years.

The quarry of the Higgins Stone Company is about one and one-half mile south of Bellevue, on the Nickel Plate Railroad. The stone, which is worked to a depth of about 25 feet, is usually in thin uneven layers, but near the base of the quarry the beds thicken, and one of two feet 10 inches was noted. Much crystalline matter, but little chert was found. Crushed stone is the product of the quarry.

About one mile farther south is the small quarry known as Flat Rock, whose chief output has been building stone for many years. At present about 8 feet of stone are worked, but formerly a few feet more were quarried, the lower courses having been abandoned because of their thickness, reported at 22 inches.

At present the thickest layer worked measures seven inches. Each bed has a blue strip in the middle with a buff one above and below. Where a crack or joint cuts the rock it also is bounded with buff, the result being that some pieces have a blue center with a lighter colored border. Such cases furnish excellent illustrations of color changes resulting from weathering. The stone is fairly even-bedded, quite crystalline, and free from chert. There are no railroad connections, and Bellevue is the principal market.

Two miles a little south of west of Bellevue, on the Nickel Plate Railroad, is the quarry of Spence Brothers, where the one product is crushed stone. A section measured here follows:

	Ft.	In.
Columbus limestone.		
Thin, and usually uneven-bedded, buff colored stone. Not well suited for building	20	--
Finely crystalline, soft stone, with buff color. Suitable for massive structures or bridge work	1	6
	1	2
	1	--
	1	--
	2	10
May split into two or more beds. Has chert layer near base	6	2

Sandusky and Vicinity.—This is one of the most important quarrying centers in Ohio. It yields great quantities of crushed stone, and is the largest producer of limestone for building purposes in the State.

Lime is burned at one place but the stone is transported from Marblehead. The largest quarries are near the Soldiers Home, but two others are found in the vicinity of Hancock street and Sycamore Lane within the city limits, while a fifth is about two miles south of Sandusky, along the Pennsylvania Railroad. In the first four of these building stone is an important product. For some miles from the city the drift is so shallow that the rock is occasionally struck in tilling the soil, and at numerous places the stone has been worked in a very small way. From this it is safe to forecast that quarrying will continue an important industry for generations, and in fact should increase rather than diminish in magnitude.

Both divisions of the limestones are present, but the Columbus only is extensively quarried. Oddly enough this division here has, in the main, the qualities of the Delaware stone, being often thin-bedded, fine-grained, compact, and having a dark-blue color. To separate the two formations, recourse must usually be had to the fossils found in them.

Section in Wagner Quarry No. 1, Near the Soldiers Home

	Ft.	In.	Ft.	In.
Thin, uneven-bedded layers, gray in color. Suitable for foundations			4	--
Building stone. Compact, even-textured, blue or brown-gray color in ledge, free from chert, and with strong odor of petroleum. No pyrite seen, but reported occasionally	--	5	8	$3\frac{3}{4}$
	--	4		
	--	4		
	--	3		
	--	$2\frac{1}{2}$		
	--	5		
	--	10		
	--	7		
	--	3		
	--	6		
	--	$1\frac{3}{4}$		
	1	2		
	--	$5\frac{1}{2}$		
	--	6		
	1	2		
	--	9		
Might be used as building stone, but now crushed. Has blue-gray tint	--	7	3	4
	--	6		
	--	9		
	--	8		
	--	10		
Not well suited for building stone. Has much pyrite. Sometimes several courses unite forming massive ledges. Fresh surfaces show a distinct blue color, but this lightens on exposure. Fossils common along bedding planes. Used for crushing	--	9	10	10
	--	7		
	1	2		
	--	4		
	1	5		
	--	2		
	2	3		
	--	11		
	1	10		
	--	10		
	--	7		

One more section will be given. This is from Wagner quarry No. 2, between the Soldiers Home and Sandusky:

	Ft.	In.	Ft.	In.
Delaware limestone.	1	8		
Blue layers containing many fossils	--	9	2	8
	--	3		
	--	6		
	--	6		
	--	4		
	--	5		
	--	4		
Columbus limestone.	--	3		
Building stone. Fairly even-bedded, and	--	7		
quite free from chert or pyrite. Compact.	--	4		
Fossils abundant. Strong odor of petro-	--	7		
leum. Layers unite and divide frequently.	--	5	9	5
Many surfaces iron stained, requiring chip-	--	5½		
ping. Blue-gray color when quarried, but	--	6½		
this changes to gray on exposure	--	5		
	1	--		
	--	10		
	--	10		
	--	5		
	--	6		
	--	6		
Suitable, but not used for building stone.				
Surfaces uneven and expensive to work.	--	6		
Difficult to break in desirable sizes. Fresh	--	10		
surfaces have a brown-gray color and a	1	--	5	4
strong odor of petroleum. Too soft for	2	--		
good crushing stone	1	--		

The sections of the two quarries just given represent very well the structure of the stone in this vicinity. It is known in the market as the "Sandusky blue stone," but the term is a misnomer, unless it is applied to the rock when freshly quarried. It rapidly weathers to a light-gray, or this color with a touch of blue. Oddly, the buff and yellow colors, resulting from the weathering of limestone at Sandusky, and other places, are not found here. No matter whether the original tint is blue-gray or brown-gray, it speedily oxidizes to a light-gray that is pleasing to the eye. In Wagner quarry No. 2, the surfaces of certain layers have some iron, most of which is chipped off by workmen. Some, however, remains, appearing as spots on the surfaces, but this, according to Mr. A. M. Wagner, disappears within a year. As proof of this he cites the main building of the Children's Home, near Sandusky, which was built of such stone.

Abundant opportunities have been had to test its durability.

The West House, erected about 1870, has walls of Sandusky stone, and these are still in first-class condition. The same is true of the High School, which bears the date 1867. The Court House, whose corner stone is dated 1872, is built of the local rock, and trimmed with sandstone, presumably the Berea. The basement courses are heavier, and look as if they came from the Columbus division. At any rate, the walls are intact, and if given the opportunity will stand for generations. Other illustrations might be cited, and all would tell the same story. The rock shows little or no disposition to scale or crumble, or in other respects give way.

It has been used extensively for churches, and is well adapted to such structures. The Carnegie Library, erected in 1901, and trimmed with sandstone, and covered with a red tile roof, appears to excellent advantage. Numerous illustrations of its usage may be found at the Soldiers Home. For residences it is satisfactory, and has led to a good market. In late years it has been used in constructing mausoleums. Perhaps it is unnecessary to add that the stone is first-class for foundations, caps and sills, and for flagging.

The stone has an extensive market in Ohio, and to a smaller extent in New York, Pennsylvania, Michigan and Indiana. In the summer of 1912, an order was being filled for a large church in Oklahoma.

Castalia.—About one and one-half miles south of this village is a quarry, operated by the Wagner Company. The upper 25 feet are of Columbus limestone, whose basal member measures about five feet. Above this the layers are rather thin, usually less than one foot, and commonly have uneven surfaces. The color is buff or gray. While this might be used for building purposes it cannot compete with the more attractive stone quarried at Sandusky and vicinity.

The lower 15 feet of the quarry were taken as a part of the Monroe limestone, which forms the summit of the Upper Silurian. It here consists of layers from one to three and one-half feet in thickness, that range in color from greenish-gray to chocolate. Where the latter color is found the rock shows numerous strips or bands, while the greenish-gray beds have dark spots. The general appearance of the rock is unfavorable for building stone.

Marblehead and Vicinity.—This is another locality where the Columbus limestone has been quarried on a very large scale. Its market is for flux, lime, breakwater, fertilizer, and to a very small extent building stone. In the quarry of the Kelleys Island Lime and Transport Company, the top 20 feet consist of thin, uneven-bedded, buff layers, not well adapted to building stone. Below this is about eight feet that may be thin or thick bedded, the variations being rapid. The lower part is brown-gray, and quite fossiliferous. When this rock

is massive it yields stone for breakwaters, and when it occurs in thin beds it yields a good building stone. Its buff color makes it warm looking, but on exposure it darkens, and becomes less attractive. What has been said about this quarry applies also to others in the neighborhood.

Johnson's Island.—This island lies in Sandusky Bay, and is about three miles north of Sandusky. The one use of the stone is for breakwaters, and when the quarry was visited in July, 1912, no blocks weighing less than three tons were removed, smaller pieces being left in the quarry. As the section below shows the stone consists of the Columbus limestone and the underlying Monroe:

Columbus and Monroe limestones.	Ft.
Gray rock, usually thin-bedded, but sometimes the reverse	12
One or more beds of brown-gray color, but changes to buff on exposure. Much chert	9
Massive bed that splits into thin layers on long weathering	4
Massive ledge, the upper seven feet probably belonging to the Columbus limestone, and the lower five feet to the Monroe	12
Brown-gray colored ledge that in places splits into several layers. Rather hard, fine-grained and compact	10

Measurements taken in different places in the quarry give very different results, from the tendency of the rock to form heavy ledges in places, and to subdivide in others. While it may be made to yield building stone, the output cannot compete with the superior grade obtained at Sandusky. The junction of the two limestones (Columbus and Monroe), is not conspicuous, except from the evidence of the fossils.

Kelleys Island.—This contains the northernmost quarries of the Columbus limestone. Work began probably more than a half century ago, and in a large or small way has been continued ever since. The stone was marketed for flux, lime and building purposes. One of the first large orders was stone for the locks of Sault St. Marie Canal, and it supplied the locks also of the present canal. For many years lime was made on a large scale, but the industry was abandoned in 1909, it having been found that the material could be produced cheaper elsewhere, as at Marblehead. At present the stone is worked extensively for two purposes, flux and lime, and to a smaller extent for breakwaters. The former has its principal market at Cleveland, Buffalo and Chicago, while the lime is burned at Superior and Duluth. The following section is from Stauffer's Bulletin:[1]

[1]Stauffer, C. R., Geol. Surv. of Ohio, Fourth Ser., Bull. 10, p. 136.

Columbus limestone.	Ft.	In.
Thin-bedded, bluish-gray limestone	10	--
Rather thin-bedded, gray limestone	5	--
Gray limestone, in three to five-inch layers	7	10
"Bottom rock," a massive layer of grayish-brown limestone, that splits on weathering into thinner beds	9	--
Gray-brown limestone, with much white to gray chert	3	6
Compact, brown limestone, with no chert	1	--
Shale parting	--	3
Massive, brown limestone	4	--
Massive, gray to grayish-brown limestone, with few or no distinct bedding planes	12	8
Crystalline, gray limestone	4	--
Monroe limestone.		
Massive, compact, dark-brown, banded limestone	2	6

The Monroe limestone, and the three bottom ledges of the Columbus, are used for government breakwaters and piers, while the higher beds, except those with much chert, are used for flux and lime. Good building stone can be secured from the Columbus beds. They are soft and easy to work, but often require considerable dressing. Detroit was a good market in former years, but no building stone at all is now gotten out.

The Northwestern District

The one quarry in this district is at Whitehouse, in Lucas County, about 16 miles southwest of Toledo. The following section is from Stauffer's Bulletin:[1]

Traverse formation.	Ft.	In.
Rather compact, crystalline, gray limestone. Containing a great many corals	--	6
Compact, finely crystalline, gray limestone	--	10
Gray to bluish-gray limestone, compact and crystalline	2	--
Compact, blue to brown limestone, markedly less fossiliferous than the other layers	1	6
Very fossiliferous, bluish to gray limestone	1	--
Columbus limestone.		
Thin, uneven-bedded, bluish-gray limestone	9	3
Bluish-gray limestone, in three to six-inch layers	1	10
Light bluish-gray limestone, in six to 14-inch layers	3	8
Massive, bluish-gray limestone, containing pockets of fossiliferous white chert	3	--
Massive, bluish-brown, crystalline limestone, weathering blue	2	--

The Columbus limestone alone concerns us in this discussion. Its top seven feet are too thin and uneven-bedded for building stone,

[1]Stauffer, C. R., Geol. Surv. of Ohio, Fourth Ser., Bull. 10, p. 149.

and are crushed for road building, ballast and concrete work. The next four feet are used in sugar beet factories and for crushing. The bottom layers, which vary in thickness, from a few inches to three and one-half feet, contain some good building stone, and were formerly worked for this purpose, the principal market being in Northern Indiana. It was used for foundations and range work, for curbings, bridges and cross-walks. With the advent of concrete the market declined, and no stone for these purposes is now quarried. It is reported that this stone began to be worked in 1872, and that 55 acres have been quarried. Lime was formerly burned.

The Bellefontaine District

The stone is nowhere quarried at the present time on a large scale in this district, and the only center of any importance in former years was at Bellefontaine. There a ledge of 29 feet of Columbus limestone is exposed, the top 20 feet being shelly, and of little use for building stone. Below this are two massive beds, aggregating about four feet, of dark-gray to brown color, that contain some chert. The lowest beds shown measure four feet, and consist of thin layers that rarely exceed eight inches in thickness. Their color is gray or drab, and some chert is found.

The only courses that could be used for building above the frost line were the two "massive beds." For underground work the "shelly" layers had a small market. From what has been said it is clear that this stone has never been of any considerable value for building purposes, and that it will not become so in the future. Lime was formerly burned, but this was discontinued about 1896. The stone's only use at present is for crushing, and it is too soft for a first-class road stone.

THE MISSISSIPPIAN LIMESTONE AS A SOURCE OF BUILDING STONE

The Maxville limestone, which forms the top of the Mississippian, and is the only limestone in Ohio in that great group of rocks, has been a small source of building stone in the valley of Jonathan Creek, at White Cottage and Fultonham. Orton speaks of it as "beautiful material, very fine-grained, quite even in color, and of great strength. It is very compact, * * *, of light-gray color, and has thus far shown no ill effects from exposure to the weather."[1] The beds vary in thickness, from a few inches to 18, the thickness increasing with the depth. The bedding is usually uneven, and the stone breaks with a conchoidal

[1]Geol. Surv. of Ohio, Vol. V, p. 638.

fracture. It is hard to work. The stone forms the walls of the Court House at Zanesville, erected in 1874, and though the beds are placed on edge they are practically as good as when laid. The structure is trimmed with Zanesville sandstone. This limestone has had a good local market for sills, caps, curbing and similar purposes, and the reports of it are altogether favorable. Quarrying for building purposes ceased years ago. Good outcrops of the formation are found to the southwest, and especially at Maxville, Perry County, from which place its name was derived.[1]

PENNSYLVANIAN LIMESTONE AS A SOURCE OF BUILDING STONE

Along the Mahoning Valley from the vicinity of Lowellville, to and beyond the Pennsylvania state line, the Vanport limestone is extensively quarried for furnace flux, ballast, and road making. On the hilltop due south from Lowellville, 17 feet of this rock is worked on a very large scale. The stone lies in fairly even layers, which vary from a few inches to five feet in thickness. The rock is fine-grained, compact, and contains few fossils. In places it is hard and chert-like, though no real chert was seen. The stone has a dark color, and appears lifeless, and this is its worst quality, viewed as building stone. Limestone from this horizon has been used in a large way in a number of the finest churches and residences in Youngstown.

The coal measures contain other limestones that are suitable for structural purposes, though no other high-grade building stone is known in them.

[1]For a detailed account of the Maxville Limestone consult Morse, W. C., Geol. Surv. of Ohio, Fourth Ser., Bull. 13.

CHAPTER III

SANDSTONES

THE MISSISSIPPIAN OR LOWER CARBONIFEROUS ROCKS AS SOURCES OF BUILDING STONE

The Mississippian or Lower Carboniferous rocks of Ohio outcrop as a broad belt, usually many miles in width, which extends from Adams and Scioto counties, on the Ohio River, nearly due north across the State to Norwalk, and thence east to Elyria and Cleveland. From the Cuyahoga Valley the outcrop extends east in a very irregular belt to the Pennsylvania line. The maximum width of outcrop of these formations is in the latitude of Ashland County, where it measures about 60 miles. The minimum figure is found along the lake shore, east of Cleveland, and in places is less than a half dozen miles in width (Fig.1).

The rocks consist essentially of sandstones and shales, which are capped in places, in Central and Southern Ohio, by the Maxville limestone. Professor C. S. Prosser has recently published an elaborate monograph, which treats in large part of the stratigraphy of the Mississippian rocks of Northeastern Ohio, and persons who desire information on this topic are referred to that volume.[1] Likewise, Professor W. C. Morse has published a good description of the Maxville limestone, which students of Ohio geology may well consult.[2]

The rocks of the Mississippian or Lower Carboniferous of Ohio have been divided by Prosser as follows:[3]

Maxville limestone.
Logan formation.
Black Hand formation.
Cuyahoga formation.
Sunbury shales.
Berea sandstone.
Bedford formation.

THE BEDFORD FORMATION

The Bedford formation has long been regarded as the basal member of the Mississippian or Lower Carboniferous, but recently certain geologists have expressed the opinion that it forms part of the Devonian. The evidence, obtained from the meager fauna found in it, is not conclusive, while structurally, the formation in most places is much more like the Devonian shales below than the Berea sandstone above. How-

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 15.
[2]Geol. Surv. of Ohio, Fourth Ser., Bull. 13.
[3]Geol. Surv. of Ohio, Fourth Ser., Bull. 7, p. 4.

ever, the question is of scientific interest only, and will not be further noticed in this bulletin.

The Bedford formation outcrops as an irregular band in Northeastern Ohio, from the Pennsylvania line west to Norwalk, where it turns due south, and continues in that direction to the Ohio River, which it reaches in Scioto and Adams counties. The formation usually varies from 50 to 100 feet in thickness, and consists in large part of shales, which are "light-blue or gray, for the most part, but sometimes reddened in the lower portion with peroxide of iron. These shales are thin-bedded, occasionally interrupted with fine-grained sandstone courses, and sometimes carrying ungainly masses of the same material, nodular or rudely concretionary in shape."[1] The formation undergoes no great change until the vicinity of Cleveland is reached, where it occasionally contains from 15 to 25 feet of fine-grained blue sandstone, that has long enjoyed a ready market for flagging, sills, caps, other forms of building stone, and occasionally grindstones and whetstones. This deposit, at any rate, in its best form, is not persistent, even in this locality, but consists rather of lenticular patches, none of which have a large area. At the present time the stone is quarried at two places between Euclid and South Euclid, and at Newburg.

Section in Cleveland Stone Company Quarry No. 25, between Euclid and South Euclid

	Ft.	In.
Glacial drift	3	--
Bedford formation.		
Shales, or thin uneven-bedded sandstone. Rejected	6	--
Thin uneven beds of sandstone. Good quality in places, but elsewhere suitable for crushing only	2	--
Thin course of sandstone. In places largely replaced with shales	--	10
Shales	--	4
Excellent course of sandstone. Surface ripple marked. Sawed for flagging, and occasionally for sills, caps, and steps	1	4
Two-foot course of sandstone. Excellent quality. Used for same purposes as overlying bed	2	--
Poor quality of sandstone. Upper surface even, lower uneven. Generally rejected	1	3
Poor quality of sandstone. Generally rejected	1	4
Heavy course of sandstone. In places of excellent quality, but elsewhere badly broken. Used for flagging, rarely for sills, caps and steps	4	9
Two-foot course of sandstone. Suitable for all purposes	2	--
Fourteen-inch course of sandstone. Good quality	1	2
Twenty-six-inch course of sandstone. Good stone in places, but elsewhere has shale bands	2	2
Dark shale, and thin-bedded sandstone	1	3
Sandstone not seen. Reported by quarryman	2	6
Shales unmeasured.		

[1]Orton, Edward, Geol. Surv. of Ohio, Vol. VII, p. 27.

These layers or beds vary somewhat in thickness from place to place, and yet comparative regularity is one of their striking features. Twenty-three feet of good stone are counted on in the best part of the quarry. Usually the beds are separated by at least a few films of shales, but occasionally one layer of sandstone rests directly on another. Even in such cases, however, the bedding planes are well marked. Cracks or other vertical breaks are fairly common, but they are not the wide or gaping variety, and the stone shows but little change in color along them. The grain is fine and even, and the rock compact. The color of the stone is blue, and it is often known as the Euclid blue stone. Following is an analysis made by Professor D. J. Demorest, of the Ohio State University.

Silica, SiO_2	76.90
Alumina, Al_2O_3	8.15
Iron oxide, Fe_2O_3	4.40
Titanium oxide, TiO_2	0.55
Calcium oxide, CaO	2.10
Magnesium oxide, MgO	0.20
Loss on ignition	4.80

Hard spots, or "hard heads," of about the hardness of steel, are occasionally found. When freshly quarried these spots have about the same appearance as the body of the stone, but on exposure their color changes to yellow or brown. Following is an analysis, made by Professor Demorest, of this variety of the stone:

Silica, SiO_2	44.35
Alumina, Al_2O_3	4.75
Iron oxide, Fe_2O_3	9.00
Titanium oxide, TiO_2	0.55
Calcium oxide, CaO	13.70
Magnesium oxide, MgO	4.40
Loss on ignition	20.00

The stone has notable crushing strength, especially when the pressure is applied on bed. Following are results of tests made by Professor Horace Judd, of the Ohio State University:

	Position. Bed or edge.	Crushing strength. Pounds.	Transverse strength. (Modulus of rupture.)
Euclid sandstone	Bed	63,460	2,596
Euclid sandstone	Edge	24,150	2,500

These tests were made on two-inch cubes for crushing strength, and pieces four inches long, two inches wide and two inches thick for transverse strength, and all were air dried. The modulus of rupture

is the weight necessary to break an inch cube when the weight is applied at the middle. The formula for determining the modulus may be found on page 76.

Professor Demorest has determined the specific gravity and porosity of the Euclid sandstone as outlined on page 77, with the following results:

Apparent specific gravity	2.336
Porosity	11.56

With all its good qualities the stone is not satisfactory for building purposes, except for trimmings, sills, caps, steps and foundations. In addition to the hard spots, which change to a brown color on weathering, some oil is present in places, and this exudes to the surface, catches dust, and of course dark patches result. Flagging is the principal use for the stone, and because of its compact texture it lasts better than the Berea sandstone. The market extends from New York to Chicago. In a small way the stone is used for grindstones and whetstones when fine-edged tools are used. The grindstones are not turned on lathes, but are cut by hand, much as was done a half century ago.

Across the road from the quarry, just described, is one of the Euclid Stone & Brick Company, in which the rock is very similar. This stone is sawed for flagging, steps, caps, sills, water tables, and much is marketed for laundry tubs, switch boards, billiard tables and lavatories. The company is now (1913) installing a plant for the manufacture of vitrified building and paving brick, and expects to use the shale above and below the sandstone. While this quarry was opened about 40 years ago, the present location was made in 1909.

A fraction of a mile southwest from the last quarry is the old Malone quarry, now the property of the Cleveland Stone Company, which was opened about 50 years ago. When visited the quarry was filled with water, but the Superintendent, W. R. Maxwell, states, that the bedding is quite unlike that in the Cleveland quarry described on a preceding page. At the top are many feet of shell-rock, and below this lies a six-foot bed which is underlain with a number of two-foot courses. The lower part of the sandstone, he says, has too much shale, and is worthless, except for crushing or rip-rap.

Only one more quarry in this locality remains to be mentioned, and that is the property of C. H. Burgess. Work was begun about ten years ago, and at first consisted entirely of crushing the waste material from the three other quarries in the vicinity. Finding the market for crushed stone good, and the supply of waste inadequate, a quarry was opened, and about 28 feet of thin uneven-bedded sandstone secured. The product is used for concrete, road making, walks, fireproofing and filtration purposes, and amounts to about 10 carloads per day.

The Euclid sandstone was discovered because of its outcrop along Euclid Creek, where quarrying of it began approximately a half century ago. At one time stone on the east bank of the creek was worked, but the deposit of high grade gave out, and since then quarrying has been limited to the west side. Men who are familiar with the locality say that the deposit of value runs east and west for about one mile, and that it is only 400 feet in width. In other words this stone is a local deposit.

Newburg.—In this vicinity, now within the city limits of Cleveland, is another deposit of the Euclid blue sandstone, and like the one previously described, it is small in area, and has long been worked. Only one quarry was in operation in 1913, and that was the property of the Caine Stone Company. It is located along Mill Creek, a short distance below Warner Road.

Section in Caine Quarry

	Ft.	In.
Glacial drift	8	--
Bedford formation.		
Gray shales	4	--
Rather soft sandstone. Occasionally splits into thin layers whose surfaces are not parallel. At its best it is sawed and used for general purposes	1	4
Thin shale parting.		
Much broken sandstone, vertically and horizontally	1	8
Shale	--	1
Heavy course of sandstone. Top 18 inches very hard, and contains shaly inclusions. While this course is occasionally used for general purposes, it is usually too hard for sawing, and hence is rejected	3	4
Shale	--	3
Good sandstone in places. Base wavy	--	10
Shale	--	2
Good sandstone, but some "hard heads" in top portion. Two inches split off from base	1	6
Good sandstone	2	3
Thin shale parting.		
Heavy course of sandstone, but sometimes divides into two, the upper one 11 inches thick. The lower part is of good quality, but the upper is too hard for the saws and is rejected	3	9
Shale	--	3
Good sandstone for flagging, but has too much iron for building purposes	2	--
Present base of quarry. Below this are reported five, nine and seven-inch courses of sandstone, which were formerly used for footing, foundations and steps.		

In general characters, especially texture and color, this stone resembles that near Euclid, already described. It is reported to be

harder, and for that reason is never used for grindstones. Vertical cracks are common, and are often stained brown on weathering. Oil spots are occasionally found, but they are not limited to one layer.

Formerly this company operated a quarry on Mill Creek, just above Warner Road, but it was abandoned about 1906. The sawmill stands on the edge of this quarry. That the deposit also is local is shown along the Belt Railroad near the existing quarry, where the rock is much broken, and thins rapidly.

THE BEREA SANDSTONE

The Berea sandstone was named by Professor J. S. Newberry in 1870, from the village Berea, in Cuyahoga County, where the stone is finely shown, and has long been quarried in a large way for building, grindstone and other purposes.

Outcrop

Since the formation lies near the base of the Mississippian, or Lower Carboniferous rocks, its outcrop is close to the junction of the Mississippian and Devonian. Beginning in the northeastern corner of the State, the Berea sandstone is found in the southeastern corner of Ashtabula County, from whence it extends southwest into Trumbull County, where it has long been the source of a lubricating oil. Near Mesopotamia, in the northwestern corner of this county, the stone was formerly quarried on a small scale for building purposes. From this locality the outcrop runs north near the western border of Ashtabula County, and in the vicinity of Windsor Mills was long quarried on an extensive scale. The outcrop continues as an irregular belt near the junction of Lake and Geauga counties, and was formerly quarried at, and in the vicinity, of Chagrin Falls, in the eastern part of Cuyahoga County. The outcrop in the latter county is extremely irregular, because of the extensive erosion of the Cuyahoga and Rocky rivers.

Continuing westward, the outcrop of the Berea forms a belt, whose northern border lies a few miles south of the lake shore, on which numerous quarries are located. At Norwalk the outcrop turns due south, and continues in that direction without notable change to the Ohio River. In this area the stone has been quarried at various places, and in nearly every county where the formation is due.

The width of the outcrop cannot be definitely stated at many places, but it varies from a fraction of a mile in parts of Ashtabula, Lake and Geauga counties, to at least 11 miles in Lorain. Farther south definite information, in most cases, is lacking, but in Franklin County the width ranges from less than one-fourth of a mile to a mile and one-half, and

in the adjacent part of Fairfield County is more than three miles. Since the formation thins to the south its outcrop narrows in that direction.

Thickness

The thickness of the Berea sandstone varies greatly from place to place. It is thickest in the northern part of the State, and thinnest in the southeastern, where drillers for oil and gas occasionally report its absence. The formation is not conformable to the underlying Bedford formation, as has already been pointed out by Professor C. S. Prosser[1] and Mr. W. G. Burroughs.[2] The rocks in which the Berea rests are not flat, but undulating, and in places sharply so. Naturally, when the sands of the Berea were spread over this surface their thickness varied much, being usually greatest in the depressions, and least on the highest points. After the sands were cemented to solid rock, and lifted above the ocean's surface, erosion began, and in places streams flowed over the shallower parts of the sandstone, cutting through that rock, and exposing the underlying Bedford formation. Thus, at South Amherst, Lorain County, where the rock is quarried to a depth of more than 200 feet, the sandstone is actually wanting in places. Facts of this kind have led quarrymen to speak of the sandstone as forming islands, and hence very uncertain in existence. A similar though less striking variation was noted at West View, on the Cuyahoga-Lorain county line. Two deep wells, perhaps 300 feet apart, and at about the same elevation, found the sandstone 52 and 150 feet thick.

Turning from these principles to figures, the Berea sandstone is 60 feet thick near Windsor Mills, Ashtabula County; 38 feet at Chagrin Falls, and 81 feet at Berea, Cuyahoga County; 29 feet near Grafton, and 212 feet near South Amherst, Lorain County; 78 feet near Berlin Heights, Erie County; 39 feet near Fulton, Morrow County; 39 feet near Gahanna, Franklin County; 31 feet near Bainbridge, Ross County; 30 feet near Waverly, Pike County, and 24 feet near Buena Vista, Scioto County, on the Ohio River.

Under cover the measurements of the Berea sandstone show great variation. Near Cortland, Trumbull County, 160 feet were found, and an equal thickness at Hazeltine, Mahoning County; at East Liverpool, Columbiana County, 69 feet; at Steubenville, Jefferson County, five feet; at Temperanceville, Belmont County, 12 feet; in the valley of the Ohio River, opposite Sistersville, West Virginia, three feet; at Macksburg, Washington County, 18 feet; at Corning, Perry County, 15 feet; at Athens, Athens County, 40 feet, and at Ironton, Lawrence County, 47 feet.

[1] Jour. of Geol., Vol. XX, p. 585.
[2] Jour. of Geol., Vol. XIX, p. 655.

Composition

The Berea sandstone does not present great variations in composition. The proportion of silica (SiO_2), is usually in excess of 90 per cent, the remaining part consisting of calcium oxide, magnesium oxide, alumina and iron, but occasionally less common bodies are found. These statements are supported by the following analyses:

Berea, Cuyahoga County.—Berea sandstone from the type locality. Analyst, the late Professor N. W. Lord, of the Ohio State University.

Silica (SiO_2)	93.13
Alumina (Al_2O_3)	3.86
Ferric oxide (Fe_2O_3)	.11
Ferrous oxide (FeO)	.54
Magnesium oxide (MgO)	.25
Calcium oxide (CaO)	.19
Loss on ignition	1.43
	99.51

South Amherst, Lorain County.—Berea sandstone from quarry No. 6 of the Cleveland Stone Company. Analyst, Professor D. J. Demorest, of the Ohio State University.

Silica (SiO_2)	92.15
Alumina (Al_2O_3)	3.85
Ferric oxide (Fe_2O_3)	1.40
Titanium oxide (TiO_2)	.40
Calcium oxide (CaO)	.50
Magnesium oxide (MgO)	.20
Loss on ignition	1.70
	100.20

Fulton, Morrow County.—Berea sandstone from quarry of Fulton Stone Company. Analyst, Professor D. J. Demorest.

Silica (SiO_2)	90.70
Alumina (Al_2O_3)	5.00
Ferric oxide (Fe_2O_3)	1.30
Titanium oxide (TiO_2)	.75
Calcium oxide (CaO)	.10
Magnesium oxide (MgO)	.20
Loss on ignition	1.70
	99.75

Waverly, Pike County.—Berea sandstone. Analyst, Professor T. G. Wormley.[1]

[1]Geol. Surv. of Ohio, Vol. V, p. 599.

Silica (SiO_2)	91.00
Alumina (Al_2O_3)	5.20
Ferrous oxide (Fe_2O_3)	1.17
Ferric oxide (FeO)	.30
Calcium oxide (CaO)	trace.
Magnesium oxide (MgO)	.28
Combined water	1.80
	99.75

The one objectionable body in the rock is iron, but not the small part shown in the preceding analyses. Occasionally nodules of this metal, varying in size from a grain of sand up to several inches in diameter, are present. On weathering these nodules change from their blue-gray color to brown, and frequently the color spreads or runs down the walls of a building, giving an unsightly appearance. Quarrymen endeavor to reject from building stone pieces which contain these concretions, and are usually successful, but since the iron bodies are sometimes not readily recognized, blocks with them are marketed for building purposes—greatly to the injury of the stone's reputation.

Quite often films of black carbonaceous material, like coal, are found. In fact, these may have a thickness of a fraction of an inch, and be very numerous. While they are not restricted to any part of the formation, they are less common at the top. They ruin the stone for building purposes, and are objectionable for all others, rip-rap excepted.

Texture

The Berea sandstone is a coarse-grained rock, that is always gritty, and this quality makes it the principal source of grindstones in the United States. With local exceptions noted below, the stone is even-grained, and increases in coarseness to the west. At only one place, Peninsula, Summit County, were pebbles found in the rock. These were of quartz, were well rounded, and attained a maximum diameter of one-half inch. However, they are not common, and are unobjectionable, except when the stone is used for grindstone purposes. Occasionally, hard places, known as "hard heads" among the quarrymen, are found. These are more compact, and the grains more strongly cemented together than in the body of the rock, and it is to the latter, rather than to a change in composition, that the hardness of the rock is due. Channeling machines striking such places have the cutting tools slightly deflected sidewise, while saws cut very slowly.

Strength

Crushing.—For determining the crushing strength, cubes were sawed, and then ground until each face measured two inches. They

were crushed in an Olsen Universal Testing Machine, by Professor Horace Judd, of the Ohio State University. Each cube had its top and bottom surfaces covered with plaster of paris, as a protection against lack of parallelism. Pressure was applied at an approximately uniform rate for about seven minutes, when the cubes cracked. Some went to pieces under the same pressure, but others required a slightly increased pressure. In all cases the crushing strength recorded below is that of cracking, and the figures are for two-inch cubes.

Crushing Strength of Berea Sandstone

Location.	Variety.	Position. Bed or edge.	Crushing strength. Pounds.
Berea	Split	Bed	25,700
Berea	Split	Edge	20,200
Berea	Liver	Bed	20,000
West View	Split	Bed	32,000
West View	Split	Edge	24,000
West View	Liver	Bed	22,500
West View	Liver	Edge	29,500
South Amherst	Split	Bed	28,000
South Amherst	Split	Edge	22,000
South Amherst	Spider	Bed	33,650
South Amherst	Spider	Edge	15,500

Transverse.—The transverse strength of building stone has usually been neglected, though it appears to be as important as crushing strength if one may judge from the broken caps and sills in many structures.

The transverse strength or modulus of rupture is determined by taking pieces a few inches long, and whose cross section is usually, but not necessarily, the same in both directions. They are supported at each end, and pressure is applied at the middle until the stone breaks. From this result the modulus of rupture is determined by the following formula:

$$R = \frac{3\,W\,l}{2\,b\,d^2}$$

w = weight which breaks the stone.
b = breadth in inches.
d = thickness in inches.
l = length in inches.
R = modulus of rupture.

In the test made for this bulletin the pieces were sawed and ground until their thickness and breadth each measured two inches. The length was approximately four inches, and the distance between the supports was three inches. The pressure was applied at the middle by a blunt, wedge-shaped, piece of steel, placed in an Olsen machine.

Transverse Strength or Modulus of Rupture of the Berea Sandstone

Location.	Variety.	Bed or edge.	Modulus of rupture.
Berea	Split	Bed	695
Berea	Split	Edge	675
West View	Split	Bed	812
West View	Split	Edge	857
West View	Liver	Bed	718
West View	Liver	Edge	698
South Amherst	Split	Bed	722
South Amherst	Split	Edge	849
South Amherst	Spider	Bed	802
South Amherst	Spider	Edge	675

Specific Gravity and Porosity

Cubes of Berea sandstone were submitted to Prof. D. J. Demorest, of the Ohio State University, for specific gravity and porosity determinations, and his communication as well as his results follow:

"I make the following report to you on the determination of the specific gravity and porosity of seven blocks of stone which you left with me. The method which I used is substantially that given by the United States Geological Survey in Bulletin 422, and is as follows:

"The blocks of stone were dried for 24 hours in an electrically heated oven at 110° to 120° C. They were then weighed. Then the blocks were placed in hot water in a tubulated desiccator, with the water extending up the sides of the blocks of stone about one-half inch. The desiccator was connected to suction pump, and kept in this condition for four hours. Then the height of the water was gradually raised until it reached the top of the blocks, but did not cover them over. In this condition the blocks were kept for 24 hours, with the desiccator continually evacuated by a suction pump. Finally the blocks were completely covered, and the suction continued for several hours more. They were then weighed while suspended in pure distilled water, and again weighed in air after moisture had been removed from the surface by means of blotting paper. The specific gravity was calculated by dividing the dry weight of the block by the difference between the weight of the block, saturated with water, and its weight suspended in water. This gave the specific gravity of the block as a whole.

"The porosity is calculated by dividing the difference between the weight of the block, saturated with water, and its dry weight by the difference between the weight of the block, saturated with water, and its weight suspended in water. In other words, by dividing the volume of the pores by the volume of the block. This multiplied by 100 gives the true percentage of the total volume of the blocks which the pores occupied."

Specific Gravity and Porosity of Berea Sandstone

Variety.	Locality.	Apparent specific gravity.	Porosity.
Spider	South Amherst	2.143	16.23
Split	South Amherst	2.189	15.87
Split	West View	2.120	16.11
Liver	West View	2.119	15.96
Split	Berea	2.086	17.78
Liver	Berea	2.086	17.83

Color

The color of the Berea sandstone is normally a uniform blue-gray. Where it is exposed at the surface, or is covered with a thin bed of drift, the color is buff or yellow at the top, and blue-gray below, the transition from one color to the other being usually gradual. In the No. 6 quarry of the Cleveland Stone Company at South Amherst, 30 feet of buff-colored stone occurs, and below this 10 feet of "discolored" rock, which consists of buff spotted with brown. Nowhere else was so much of the buff variety found. At Berea, where the sandstone is covered with a bed of impervious shales, the buff color is of course absent.

The color of the stone is due to the iron present and to its composition. Where the iron is in the form of a lower oxide (FeO), the color of the sandstone is blue-gray, but where the iron has been long exposed to the atmosphere it changes to a higher oxide (usually $2Fe_2O_3$, $3H_2O$), and the color of the rock becomes buff or yellow. From this it follows that the blue-gray stone, when exposed, as in the wall of a building, changes its color, first losing the blue tint and becoming gray, and later, owing to further oxidation of the iron, buff. Where change is not uniform, and the stone is marred with brown spots, the appearance is very displeasing.

Structure

The following varieties of structure are recognized in the Berea sandstone of Northern Ohio:

1. Shell-rock.
2. Split-rock.
3. Liver-rock.
4. Spider-web rock.
5. Cross-grained or cross-bedded rock.

Shell-rock.—This consists of thin layers, usually less than six inches, whose surfaces may be parallel or at low angles. Where present it is found at the top of the quarry, and always has a buff color. Its structure is doubtless due to breaks in deposition, rather than to subsequent action by frost or other forces of destruction. The maximum thickness of shell-rock was found in the Kipton quarry, about four and one-half miles northwest of Oberlin, where it measured 32 feet. Shell-rock is useless except for ballast and similar purposes.

Split-rock.—As its name indicates, this variety splits into thin layers. It is used for building stone, curbing and grind stones. Formerly

it was split for flagging at Chagrin Falls, but usually it cannot be separated into large enough slabs for this purpose. Split-rock usually shows distinct lines parallel to the bedding plane, and by these its character is recognized. Its structure has resulted from the sand having been deposited in even layers, with the longer axes of the grains parallel to the bedding planes. This variety is suitable for all purposes for which the Berea sandstone is adapted.

Liver-rock.—This variety is characterized by the absence of well-marked structural features. It consists of a homogeneous mass that works practically as well in one direction as in another. While it may be used for almost any purpose it is especially adapted for grindstones. The sand was laid down without the sorting or orientation among the grains that occurred when split-rock was deposited.

Spider-web.—This variety shows lines of deposition similar to those in split-rock, but with the important exception that the lines are not parallel to each other or the bed. In fact, the lines form a festoon or network, hence the name spider-web. The structure appears to be a fine or delicate variety of cross-bedding. The rock makes excellent grindstones and building stone, and when sawed is first class for curbings and flagging. Good illustrations of this are not found at Berea, but it is important at South Amherst. Generally it lies some distance below the surface of the quarry.

Cross-bedded.—Quarrymen call this variety cross-grained, and one name is about as suitable as another. The grain of the rock is usually distinct, but the layers are not parallel, except occasionally for short distances. The layers may run in straight or curved lines, and may change their courses rapidly. This structure seems to have been formed by currents, whose direction and velocity were changing, by variation in the supply of sediments, and by the topography of the surface on which the sands were deposited. The rock is used for grindstones and structural purposes. As a rule it is more difficult to quarry and work than the other varieties.

Below the shell-rock the formation is usually massive. However, at Berea, the type locality, beds are well defined, and are in places separated by a few inches of shales. At West View the shale partings have disappeared, and while an occasional well-marked horizontal break exists, the rock is in large part massive. Elsewhere in Northern Ohio no real bedding planes exist, but horizontal breaks appear and disappear frequently. These breaks may vary in length, from a few feet to a hundred, or even more, but they are not continuous, in the sense, of extending across large quarries. Further, when a break disappears, if it is succeeded laterally by another one, it is at a higher or lower level. Commonly, these breaks are not sufficiently complete so that quarrymen can lift off the overlying bed, and the men, there-

fore, drive wedges in the fissures, thus completing the separation. Not uncommonly streams of water issue from these crevices in the quarry walls, and provide the workmen with excellent drinking water. Ripple marks are common, and may be expected wherever bedding planes are well developed.

Vertical breaks are still less common than horizontal ones, and in consequence blocks of almost any area can be quarried. Occasionally fissures cut the beds at a sharp angle. These cracks, known as cutters among the quarrymen, may have a length of a few feet or many. In some places thay are scarcely visible, but elsewhere their presence is indicated by a buff streak, or occasionally by a light gray. The former color is doubtless due to oxidation, the crack serving to admit the atmosphere, while the gray has resulted from the deposition of silica in the crack. Sometimes the walls along the fissure are so thoroughly cemented that the rock can be used for almost any purpose, but generally the "cutters" represent lines of weakness, and render the stone useless except for rip-rap.

While the general dip of the rock is southeast there are many exceptions, and this is readily comprehended when the uneven floor on which the Berea sands were laid down is recalled. In the two larger quarries at South Amherst, the dip of the rock is nearly everywhere towards the center, that is, basin-like, and probably this explains the great thickness of the formation at that place.

Quarries in Berea Sandstone

The Berea sandstone has been quarried in Ohio, in a large or small way, in nearly every county where the formation outcrops. In reviewing these quarries we will start ir the northeastern part of the State, and follow the outcrop west to Norwalk, and thence south to the Ohio River.

Mesopotamia.—This village, which is situated in the northwest corner of Trumbull County, was for many years the site of a quarry which supplied stone for the surrounding county, and for the following data concerning it the Survey is indebted to Mr. W. G. Burroughs of Oberlin.

The quarry is in the valley of Andrews Creek, about one and one-fourth mile southwest of the village, and is now the property of Charles Clark of Warren. The quarry is about 400 feet long, and the sandstone is covered with from 10 to 20 feet of glacial drift.

This quarry was opened about 50 years ago by Harrison Clark of Mesopotamia. The stripping and quarrying were, of course, done by hand labor. When the rock was very hard, blasting was resorted to, but at other times the stone was broken with wedges in the usual

manner. Six men were the most ever employed at one time. The quarry has not been in active operation since 1890. A section in this quarry follows:

	Ft.
Glacial drift	10–20
Berea sandstone.	
Sandstone layers from one to six inches thick. Ripple marked. Many iron stains	20
Gray-blue shale, rather soft. Contains one thin layer of sandstone	6
Sandstone layers from eight to eighteen inches thick. Light-gray, rather fine-grained and soft. Contains few iron impurities	20

From a well record farther down stream the total thickness of the formation was proven to be as follows:

	Ft.
Berea sandstone	20
Shale	6
Berea sandstone	36

A little farther down stream was a smaller quarry, in which the lower part of the sandstone was worked from 1874 to 1889.

Neither quarry had railroad connections. The chief use of the stone was in bridge work on public roads, but smaller quantities were used for foundations, flagging, sills and caps. Orton considered it of excellent quality. Lack of shipping facilities, and the competition of cement, were too much, and the quarries were forced to close, though a little stone is still occasionally gotten for use in the neighborhood.

Windsor Mills.—This hamlet, located in the southwestern corner of Ashtabula County, was for many years the site of important quarrying operations. For the following facts the Survey is again indebted to Mr. W. G. Burroughs.

The ownership of the land on which the quarries were located was for more than a century in the Alderman family. When quarrying first began is not known, but the stone outcrops in the bed of the creek and was probably used by the early settlers. The Windsor Stone Company was incorporated for $100,000, and in the latter part of 1890 the quarry was opened. When in full operation the plant was equipped with a sawmill, two channeling machines, drills, and all the necessary tools and appliances for a first-class quarry. Lack of shipping facilities was overcome by the construction of a railroad to Burton Station on the Baltimore & Ohio Railroad, eight and one-half miles distant. However, the quarry was not a success, and continued under the original management only about one season. It was then leased on a royalty basis, but little or no work was done later than 1893. The railroad was not in running condition after 1894 and the rails were taken up in 1897. A section of the rocks in this quarry follows:

Section at Windsor Mills

	Ft.	In.
Glacial drift	12	--
Sunbury shale, black	20	--
Berea sandstone.		
Sandstone, very hard, brown, stained with iron spots	1	5
Gray-blue shale, moderately soft	9	7
Sandstone, ripple marked in upper part. Layers vary from shells to four feet in thickness. Medium grain, light-gray to buff color and speckled brown with iron spots	49	--
Bedford formation.		

Examination of blocks of stone lying around the old quarry showed a gray color with but little iron staining. A freshly broken surface gave a light-gray tint speckled with brown iron spots. The grain is medium and the stone rather soft. Mr. J. L. Kirk, the present owner of the quarry, says, "from core drills the stone gave evidence, when the tools reached the lower strata, that the rock has a remarkably good color, fine grain, and would be very easily shaped, hardening on exposure. It was thought that some of the upper strata, which also carried a good color, might be used for superstructures of buildings, and several carloads were shipped for this purpose, but had to be culled to discard such blocks as contained iron shot, which on exposure rusts in spots from one-half to one inch or more in diameter."

Mr. Kirk assigned the following reasons for closing the quarry: "The stone near the surface was hard, and came into competition with other stone that could be sold for less. The quarry was opened in a field and there was no place to dump refuse except in the vicinity of working operations, with the result that there was always an accumulation of stone and rubbish around the quarry that had to be handled several times before it could be gotten out of the way. Each layer of stone seemed to furnish a fresh water supply, until at last it became very expensive to keep the quarry workably dry."

Orton describes the stone "as much inferior to that to be obtained over quite an extent of country from Berea, Cuyahoga County to Berlin Heights, Erie County. The pyrite and protoxide of iron contained in the stone at Windsor produce bad discoloration on exposure to weather. As a source of material for heavy masonry this locality is invaluable, as Ashtabula County has no other stone well adapted for this purpose, and the Windsor quarry has furnished a large amount of stone for every bridge construction on the railroads and highways in this county."[1] However, the general use of cement in bridge and foundation work has destroyed the market for which the stone is well adapted.

About one mile north of Windsor Mills is the hamlet Stoneville, which was formerly an important quarrying center. The old quarry

[1]Geol. Surv. of Ohio, Vol. V, p. 579.

is now filled with water and hence good exposures are out of the question. Doubtless the quality of stone here is similar to that at Windsor Mills, and the quarry was abandoned for like reasons.

Lake County.—The Berea sandstone, according to Mr. W. G. Burroughs, was formerly quarried by Theodore Curtis in Concord Township, about four and one-half miles north of Chardon. As now exposed the formation shows a five-inch layer at the top, underlain by a massive bed 41 inches in thickness. Rubbish and underbrush conceal the lower part of the sandstone so that nothing definite can be said of it. Fresh surfaces of the rock have a light-gray color, but where weathered the shade is red-brown. The quality of the stone is not first-class, but was used for foundations, bridges, etc. When cement came into general use the demand for this stone decreased to such an extent that the quarry was compelled to close.

Geauga County.—In 1884 J. H. Curtis opened a quarry on the Mummery Farm, about four miles west of Chardon, but it was never a real success. In 1897 it passed into the hands of D. V. Moyer, and later came into the possession of the present owner, Adelbert Whitson. Mr. W. G. Burroughs, who visited the old quarry, states that the rock is covered with five feet of glacial drift. Beneath this is two feet of sandstone consisting of layers about two inches in thickness, and below this a massive bed from one to two feet in thickness. Exposed surfaces were brown from iron stains, but when freshly broken the rock had the usual light-gray color.

The grain is reported medium in size and the rock was used for grindstones, but could not successfully compete with the product from Cuyahoga and Lorain counties. The stone was used also for structural purposes, but it was not able to hold its own when the use of cement became general, and the quarry was abandoned.

Chagrin Falls.—Berea sandstone is well exposed in the valley of the Chagrin River, in the vicinity of the village Chagrin Falls, and the stone has been quarried since colonial days. In the old Goodell quarry, a short distance above the falls, the following section was obtained:

	Ft.	In.
Drift, unmeasured.		
Sunbury shales, unmeasured.		
Berea sandstone.		
Hard rock, would not split, used for foundations only	3	6
Thin beds, ranging from one-half inch to 10 inches. Used for flagging, steps, caps and sills	4	--
Split rock. Split into four layers for flagging. Used also for curbing, and in mass for bridge work	2	--
Used for foundations	--	11
Heavy beds reported. Not worked.		

The rock was never worked on a large scale, nor was it sawed. The stone contained too much iron for a first-class building stone,

and the lack of railroad connection worked further hardship, so that the quarry was abandoned about 1908. The sidewalks in Chagrin Falls are from this quarry and they give it an excellent reputation. Some grindstones were made. According to Prosser the thickness of the Berea sandstone in this vicinity is 38 feet.[1]

About two miles southwest of Chagrin Falls on the Aurora Branch of the Chagrin River a quarry was opened in the Berea sandstone. At first the rock was quarried in the river bed, the base of the stone being there exposed, but the main work was on the bluff where the following section was found:

Section on Aurora Branch of the Chagrin River

	Ft.	In.
Sunbury shales, unmeasured.		
Berea sandstone.		
Shell-rock	1	6
Splits into two layers in places, replaced by shales in others	3	--
Massive layer	6	--
Shales	--	6
Massive layer, cross-bedded	6	--
Layer whose base was not seen. Very cross-bedded	3	--

The stone in this quarry is unusual in that it is all of buff color. It is too soft for flagging and was used for building stone, curbing and grindstones. The waste material was crushed to sand and used in steel works. The quarry was equipped with a good sawmill and lathes for turning grindstones. The stone, however, varied much within a small area, making quarrying uncertain, and the heavy overburden, amounting in one place to at least 30 feet, rendered work unprofitable, and the quarry was abandoned.

About 15 years ago the Bancroft quarry was opened a mile and one-half northwest of Chagrin Falls, and the Berea sandstone worked in a small way for flagging, curbing and building stone. The quarry was without railroad connections and was closed about 1907.

Berea.—We have now arrived at the village Berea, the place from which the formation was named, in our discussion of quarries in the Berea sandstone. Berea is situated near the western edge of Cuyahoga County on Rocky River, in whose bed and bluffs, and in that of its tributary, Baldwin Creek, the formation under consideration is exposed.

Pioneers who settled in this locality in the first quarter of the last century, noticed the thin slabs of sandstone exposed in the beds of the streams, and soon found that it yielded a better grindstone than those they were importing at great expense from Nova Scotia. They broke

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 15, p. 206.

A.—Orton Hall, Ohio State University, built entirely of Ohio stone. The basement walls are of Dayton and Springfield limestone. The superstructure is of Berea sandstone from South Amherst, trimmed with brown sandstone of Cuyahoga age from near Carroll, Fairfield County.

B.—Quarry in Berea sandstone at Berea.

the slabs into squares, carted them home, then knocked off the corners and smoothed the edge as best they could, and finally cut a square hole in the center when the stone was ready for the frame.

John Baldwin, who emigrated from Connecticut to this vicinity in 1828, was quick to perceive the possibility of the grindstone business, and at once began making them in his cellar for the neighborhood pioneers. The business increased, and in 1832 Baldwin employed two workmen to assist him. Money was scarce and the men's compensation consisted of one-half of the grindstones, but in the following spring Baldwin purchased the workmen's share and disposed of the entire lot to a trader who shipped them to Canada.

Naturally the stone was used for building purposes, especially foundations, and walks, by the early inhabitants, and in this way it established a good reputation locally. Among the earliest shipments of stone were to Cleveland where it was used in building a jail. Unfortunately the stone was not carefully selected and soon developed "iron and sulphur" spots, which injured it in that market for a long time. For many years the quarries were without a railroad, but in 1849 the "Big Four" was constructed, though it did not approach nearer than a mile to the quarries. Baldwin, however, built a switch along the principal street of the village, using the old fashioned flat-rail with cars drawn by ox teams, and in this way connected his quarry with the new railroad. In a few years "pony" engines replaced the oxen, and about 1860 the railroad company, seeing the possibility of the quarries, built a switch at its own expense, and since that time the transportation facilities have been adequate. With the rapid growth in population and industry, the demand for stone increased, and Berea soon became known as the source of the best light-colored sandstone in this country.

As the demand for the stone grew new companies were formed. Among these were Lyman Baker & Company, F. M. Stearns, R. W. Wood & Company, Geo. W. Whitney and C. W. Stearns. In 1871 these interests were consolidated under the name Berea Stone Company, with capital of $500,000. The quarries covered about 40 acres and gave employment to 100 men. In addition to large quantities of stone for structural purposes about 3,000 tons of grindstones were produced annually.

The Baldwin Quarry Company was chartered in 1873 with $160,000 capital. Its quarry comprised about 10 acres, and employed from 40 to 60 men. In 1878 Russell & Forche succeeded the Diamond Quarry Company, and gave their entire attention to producing stone for building purposes and flagging. They claimed to have produced 30,000 tons of stone the first year of their organization. The Empire Stone Company began operations in 1874. It shipped about 300

tons of grindstones yearly, and from 40 to 100 tons of building stone daily.

J. McDermott & Company, whose operations at Berea dated from 1853, became a chartered corporation in 1873, with capital of $250,000. Their quarry covered from 30 to 40 acres and employed 150 men. The production was 400 tons of building stone and grindstones per day. Much of the former was shipped to Canada, while the grindstones went to various parts of the United States, Australia, Europe, and other foreign countries.[1]

In 1886 the Cleveland Stone Company was organized, and it took over the quarries which were in operation. A year later the company purchased the 45 acres of land on which Baldwin University was located, for $90,000, and the Institution secured its present location. Improved methods of quarrying were introduced, and the industry as we find it dates from the organization of the Cleveland Stone Company. The quarries lie east and southeast of the village, and a large area, estimated at 125 acres, has been worked over.

Section in "No. 9" Quarry of the Cleveland Stone Company at Berea

	Ft.	In.
Glacial drift	10	--
Sunbury shales	25	--
Berea sandstone.		
Shell-rock. Many ripple marks. Rejected	2	--
Cross-bedded. Sawed for curbing, flagging or grindstones	1	9
Split-rock, but in places cross-bedded. Occasionally this layer and the one above unite	2	--
Thin layer, rejected	--	4
Heavy course, split-rock in places, but liver-rock in others. Used for split curbing and sawed for flagging, rarely for grindstones. Upper surface wavy	6	1
Thin layer. Generally rejected	1	3
Heavy course. Generally cross-bedded. In places the upper surface is as smooth as if sawed, but elsewhere it unites with the overlying bed, and the two split with an uneven surface. Used for grindstones, flagging and curbing	6	--
Not seen. Layers reported uneven and with many iron streaks	60	--

As a rule the several beds worked in this quarry are free from each other, but occasionally this is not true, and then separation is effected by driving steel wedges between them. The courses vary in thickness, and the section given might not be duplicated in any other part of the quarry. The varieties of rock found are shell, split, liver and cross-bedded, and these vary much from place to place. In other words, a bed of split-rock may rapidly change to liver, or even cross-

[1] Historical data from History of Cuyahoga County, compiled by Crisfield Johnson, 1879. The statements in this volume relating to the stone industry at Berea are said to have been supplied by John Baldwin, Sr.

bedded, so that the workmen cannot forecast what they will find a few feet in advance. Concretions of iron are not uncommon and but little of this rock is marketed for building purposes. The thickness of the formation is given at 85 feet. The 30 feet of rock below the base of this quarry are reported to be massive, and hence not easy to work. Further they have occasionally hard or "flinty" spots and the texture is irregular.

Section in "No. 6" Quarry of Cleveland Stone Company Near the Southeastern Corporation Line of Berea

	Ft.	In.
Glacial drift	5	--
Sunbury shales	35	--
Berea sandstone.		
Shell-rock. Rejected	--	6
Liver-rock. Thins to the south and underlying bed thickens. Sawed for grindstones, flagging, and curbing	3	10
Shales	--	2
Liver-rock. Thickness increases to the south. Upper surface ripple marked. Sawed for grindstones, curbing and flagging	4	4
Shales	--	3
Lense-shaped bed. Sometimes it disappears by uniting with bed below	1	4
Liver-rock. Thins to the south. Upper surface shelly and ripple marked. Sawed for curbing, flagging and grindstones	6	--
Liver-rock. Top two to three inches shelly and ripple marked. The best of this course is sawed for same purposes as those above; the poorer is used for breakwater purposes	7	8
Base of quarry.		

As the section shows, liver-rock is the common variety, but this changes suddenly in places to the cross-bedded structure. Occasionally slate colored nodules of sandy clay are found scattered through the beds, and in places these form more or less regular bands or stringers. They are darker than the enclosing sandstone and on weathering change to brown. The individual nodules are usually less than two inches in diameter. Hard or "flinty" concretions are found, and range from an inch to a foot, or even more, in diameter. They make trouble for the channeling machines and saws, and render the rock unfit for grindstones, since even hardness is required for this purpose.

About three and one-half miles northeast of Berea is a quarry of the Middleburg Stone Company, which was opened in 1901. At first the stone was quarried for building purposes, curbing, flagging, and especially for grindstones. The market for the latter increased rapidly and was more profitable, so that for the past few years the company has given all its time and energy to the manufacture of grindstones.

The latter vary from one to seven feet in diameter, and the output ranges from 500 to 600 tons per month. The stone is considered a little coarser than at Berea, and so is better suited for the larger stones. Below is a section taken in this quarry:

Section in Quarry of the Middleburg Stone Co., Near Berea

	Ft.	In.
Drift	3	--
Berea sandstone.		
Shell-rock	11	--
Hard course. Used in places, but too hard in others	7	6
Liver-rock	32	6
Course containing many coal films or thin layers and "flint" nodules. Not quarried	8	10

The rock is without bedding planes, but discontinuous horizontal cracks are common, and are a great aid in quarrying. For this reason the thickness of the blocks quarried varies. The color of the stone is buff near the top and blue-gray below. Tests with the drill show the formation varies from 67 to 82 feet in the tract of nearly 100 acres owned by this company.

Peninsula.—This village, which lies in the valley of the Cuyahoga River in the northern part of Summit County, has long been a source of Berea sandstone. Following is a section taken in Quarry No. 16 of the Cleveland Stone Co., located about three-fourths of a mile up the river from Peninsula.

Section in Quarry No. 16 of the Cleveland Stone Co., Near Peninsula

	Ft.	In.
Glacial drift	6	--
Sunbury shales. Thickness varies, owing to the unequal erosion of its surface	9	--
Berea sandstone.		
Course whose top foot breaks into chunks and is worthless. The remaining eight feet of the rock were once a favorite building stone, and are now used principally for grindstones. Small quartz pebbles occasionally are found. Color buff. Cross-bedded in places	9	--
Blue-gray stone, formerly used for building purposes, but now sawed for grindstones and flagging, and to a small extent for sills and caps. Cross-bedded in places. Small quartz pebbles are occasionally found near the top and harder streaks near the base	16	--
Too uneven in hardness for grindstones. Sawed for flagging. Split-rock in places	8	--
Not seen. Reported much broken, and to contain many bands of "flint." Not worked	10	--
Bedford formation.		

No real bedding planes are found in the Berea at this place, and the horizontal separations are made by the use of steel wedges. Vertical fissures are much more common than are found elsewhere in this formation in Northern Ohio.

Quarry No. 15 of the Cleveland Stone Co. is located about one-half mile west of Peninsula, and was opened about 1903. The formation measures 46 feet, and all of it is quarried. Formerly there were 15 feet of split-rock which was used for split curbing. The stone is used for grindstones, and flagging, and to a small extent for building stone. The upper 10 to 12 feet are too hard for grindstones, but are well adapted for flagging. The basal foot in the quarry is "flinty" in places. The rock is gray in the upper part and blue-gray below. Its structure is similar to that in quarry No. 16, already described.

Westview.—This village lies two or three miles southwest of Berea, and has long been an important quarrying locality. Below is a section in quarry No. 3 of the Cleveland Stone Co.

Section in Westview Quarry No. 3.

	Ft.	In.
Glacial drift	25	--
Berea sandstone.		
Thin and uneven beds. Worthless	7	--
Used for small grindstones	5	--
Poor quality. Used for breakwater only	7	--
Used for small grindstones	5	6
Soft and specked with brown iron stains. Used for grindstones	10	--
Used for grindstones	4	6
Coarse. Numerous brown iron specks. Used for grindstones	12	--
Sometimes has slate colored, egg-shaped nodules that are harder than the enclosing rock. Used for grindstones	6	--
Split-rock. Free from iron specks, but contains black carbonaceous films. Used for grindstones	8	--
Good clean stone. Used for grindstones	10	--

The rock in this quarry is quite uniform and of the liver variety, except course 2, which, as the section shows, is split-rock. The thickness of the beds changes rapidly, amounting in some cases to as much as two feet in a face 85 feet long. The only well-marked bedding plane is found between courses 2 and 3. This rock has been sawed for sills, caps and flagging, but its coarse, even grain, makes it especially adapted for grindstones of large size.

On the bank of Rocky River near this quarry two deep wells were drilled in 1888 for natural gas. They were about 100 yards apart, and at approximately the same elevation; yet one found 52 feet of sandstone and the other 150 feet. This great difference is explicable

only on the theory that the base of the sandstone is very uneven, that is, rises and falls with the surface of the shales on which the sandstone rests. Below is a record of well No. 2, the stratigraphical names having been supplied by some unknown person:

	Ft.
Clay	15
Berea sandstone	52
Bedford shales, red	68
Bedford shales, light	15
Cleveland shale	100
Erie shale	380
Huron shale	386
White shale	39
	1,055

Gas was found at 255, 620, 650 and 915 feet, and is still used for light in the sawmill of Westview quarry No. 3.

A short distance north from the quarry just described, is Westview quarry No. 2 of the Cleveland Stone Co., which is said to have been opened about 1880. Twenty-five feet of Berea sandstone are worked, but the upper seven feet are shelly and hence rejected. The rock below is decidedly uneven in structure. Much of it is cross-bedded, and in places contains hard knobs, which render it unfit for grindstones. Black carbonaceous streaks are common. A small part of the rock is sawed for curbing, but much the greater portion is used for grindstones.

Columbia.—The quarry of the Columbia Stone Co. is situated in Lorain County about two miles southwest of Westview, and about one-half mile northeast of Columbia Station on the "Big Four" Railroad. The locality has long been an important quarrying center, the Cleveland Stone Company formerly having worked the stone at this place.

Section in Quarry of Columbia Stone Company

	Ft.	In.
Glacial drift	30	--
Berea sandstone.		
Medium grain. Used for small grindstones and building stone	4	--
Hard stone. Used for sills and flagging	4	6
Used for grindstones and building stones	7	6
No. 1 stone. Suitable for all purposes	10	--
Top four feet used for small grindstones; next two feet cross-bedded, used for building stone; lower three feet split-rock, used for sills	9	--
Rather coarse-grained; used for large grindstones, and suitable for building stone. Has some carbonaceous streaks	8	--
Suitable for all purposes. Contains numerous carbonaceous streaks	16	--

In a number of places unusual breaks for the Berea sandstone were found. These consisted of beds of shales from six inches to three feet in thickness, with included chunks of sandstone, some angular and others rounded. Some of these pieces are brown with iron stains, and others show a concretionary structure. The masses cut across the sandstone to a depth of perhaps six feet, at an angle from 10 to 20 degrees. The contact with the sandstone above and below is very uneven, and in places the transition from shale to sandstone is sharp, while in other places it is gradual. This structure suggests an uneven sea floor on whose depressions a layer of mud accumulated with batches of sand, which in turn, in whole or in part, were covered with mud, and finally the entire mass buried in sand.

This quarry is a source of considerable building stone of good grade. Not only is the stone sawed on four sides when demanded, but the mill is equipped with a planer, and besides has a force of stonecutters who finish the work by hand. Grindstones of all sizes are made.

South Amherst.—This location is two miles south and one mile west from Amherst, Lorain County, and at the present time, as for some years past, is the most important locality for quarrying the Berea sandstone in Ohio. It is also the principal source of building stone from the Berea horizon, for the rock is freer from iron spots than at any other place in Ohio.

The sandstone in places is barely covered with drift, and it must therefore have been known to the pioneers as soon as they located in the vicinity. Mr. George Rice, who has resided near the present quarries for more than threescore years, states that stone was hauled from there to Oberlin about 1855. Doubtless it was quarried in a small and discontinuous way long before that time. About 1869 Cook & Wilson opened what is now the great No. 6 quarry of the Cleveland Stone Co. After operating it a short time they sold the property to a Mr. Cromwell of New York City, who formed the Amherst Stone Co., and put his son and a Mr. Bingham in charge, the principal business being the manufacture of grindstones. Later this property was bought by the McDermott Company of Berea, who operated it a short time, and then disposed of it to the Halderman Stone Co., who remained in possession until the Cleveland Stone Co. was formed in 1886, when it became a part of that great corporation.

About 1888 the Halderman Stone Co. opened a quarry just west of the one sold, and for some years operated it under the name Ohio Stone Co., but it in turn also was absorbed by its ambitious neighbor, the Cleveland Stone Co. The Malone Stone Co. was organized about 1870, and opened a quarry about one-fourth of a mile southeast of what is now the No. 6 quarry, but this also was taken over by the Cleveland Stone Co. Another early organization was the Mussey

Stone Co., who opened a quarry just south of the No. 6 quarry, and across the road from that of the Malone Company referred to above. This property also is now a part of the Cleveland Stone Co. The last organization to enter the field was the Ohio Quarries Co., which was organized in 1903 by John R. Walsh of Chicago. This company maintains an independent existence, and is a large producer of stone. Its two quarries are immediately south of those of the Cleveland Stone Co.[1]

Section in the No. 6 Quarry of the Cleveland Stone Company at South Amherst

	Ft.
Glacial drift	4–10
Berea sandstone.	
Shell-rock. Thrown on dump or used for ballast	15–20
Buff-rock, in places shelly. Used for grindstones, and to a small extent, for building stone	10
Discolored rock. Buff, with brown spots. Used for bridge work and rip-rap	8
Spider-web. Used for flagging, steps and sills, the softer parts for grindstones	16
Cross-bedded. Used chiefly for rip-rap and breakwater. Occasionally used for flagging	10
Split-rock. Used for building stone, flagging and curbing, the softer parts for grindstones. This is marketed under the name Gray Canyon sandstone	25–30
Cross-bedded. Chief uses for rip-rap and breakwater	12
Split-rock. Used for building stone, flagging and curbing. Too hard for grindstones. Marketed as Gray Canyon sandstone	26
Spider-web. Sawed for sills, steps, or flagging, and marketed as Gray Canyon sandstone	10–12
Base of quarry, but not of Berea sandstone.	

As the section shows, the top of the rock is shelly, but below that it is really one great mass. This contains numerous horizontal cracks which extend for perhaps 50 feet and then disappear. The rock is broken horizontally by driving rows of steel wedges in these cracks when present, or when absent at such depths as will give the desired thickness of stone. Vertical cracks known as seams are present, but they are neither conspicuous nor numerous and play but little part in quarrying. Dark iron spots exist. They are not restricted to any part of the quarry, nor can any part be rated as certainly free from them.

The color of the stone varies. Not being covered with shales, or any other impervious body, the upper part of the sandstone has been

[1]Historical data largely by C. W. McCormick of the Cleveland Stone Company.

Great quarry in the Berea sandstone of the Ohio Quarries Company at South Amherst, Lorain County. Depth about 200 feet.

oxidized to a buff, whose shade varies horizontally and vertically. Below the "discolored" bed the rock is everywhere blue-gray, and the shade is uniform.

The shape of this quarry is an immense rectangle, and from three of the corners the rock dips toward the center. From the fourth corner the rock dips away from the center, that is, to the southeast. The plants of the Cleveland Stone Co. at Amherst employ approximately 550 men, and ship on the average about 35 cars of stone per day the year around. This includes the stripping, which is removed in winter, and used by the railroads for filling. The stone is marketed under the name Buff and Gray Canyon sandstone. The name gray has been adopted to meet the popular objection to the name blue, under which it was formerly marketed. One hundred and seventy-five feet of stone have been removed in this quarry.

Section in Buckeye Quarry, South Amherst

	Ft.
Glacial drift	4–10
Berea sandstone.	
Shell-rock	6–15
Spider-web. Best sawed for flagging or grindstones, the rest used for rip-rap	35–40
Split-rock. Used for building stone, curbing or grindstones	15–35
Cross-bedded. Sawed for curbing or grindstones	8–25
Spider-web. Sawed for building stone or flagging, and rarely for grindstones	6–12
Split-rock. Used for building stone, grindstones and curbing	95
Cross-bedded, and with dark spots. Not quarried	6

The above section represents the rock as found in the east end of the quarry. The shell-rock is buff and all below is blue-gray. However, in the west end of the quarry, 10 feet of good buff were found, though in the northwest corner the same bed was blue-gray. The rock changes more rapidly in texture than it does in color, split-rock to spider-web or cross-bedded, and vice versa, so that it is not possible to forecast many feet in advance what the nature of the rock will be.

Hard spots, called "hard heads" by the workmen, are occasionally found. They may have the same color as the enclosing rock, that is, blue-gray, or rarely buff or brown. They are always harder than the body of the rock. Small dark "bird-shot" or "buck-shot" are occasionally found. As may be surmised these are small concretions of iron, and are highly objectionable where the stone is used for building purposes. Efforts are made to prevent any such pieces from being marketed for building stone.

Cracks or seams are uncommon, and appear to be most numerous

at depths. Cutters or closed cracks are occasionally found, especially in the west end of the quarry, and their color is buff or light-gray. The dip of the rock from the two ends of the quarry is toward the center. What was said about horizontal cracks in the No. 6 quarry applies equally well to this one. Likewise, what has been stated about "hard heads" and "bird-shot" in the Buckeye quarry is as well suited for the No. 6. Black carbonaceous films or thin layers are occasionally found in all these quarries.

The maximum thickness of the sandstone found in the Buckeye quarry is given at 212 feet. All in all, it is the finest deposit of this kind of rock known in Ohio, and the quarry and mills are the most up-to-date. The stone is marketed under the name Buckeye Gray Sandstone. About 375 men are employed, and the output, including the stripping in winter, averages approximately 32 cars per day.

Amherst.—Approximately one and one-half miles west from Amherst is the quarry of the Breakwater Company. This was opened about 1904 by the Independence Stone Company, who disposed of it, perhaps in 1909, to the present holders.

Section in Quarry of Breakwater Company

	Ft.
Glacial drift	2
Berea sandstone.	
Shell-rock	2–12
Split-rock. Sawed for flagging; used also for capping in breakwater	½–4
Cross-grained. Used for breakwater purposes	6–8
Spider-web. Sawed for flagging; used also for breakwater	8
Sandstone and soapstone. Worthless	2
Spider-web. Sawed for flagging; used also for breakwater	3
Bedford shales.	

The stone in this quarry is used for two purposes, flagging and breakwater. Formerly it was a source also of building stone, curbing and grindstones. Much of it, however, was not suited to these and gradually its use was restricted to the two named above. About 60 men are employed on the average, and the output is given at 18,000 tons of stone for eight months. The stone varies much in structure and in places large proportions are cross-bedded. Ripple marks are common, and the stone dips at a sharp angle, occasionally 30 degrees. Further, "hard heads" and chunks of clay are included in the rock. From what has been stated it is clear that the rock in this quarry is not first-class, but it answers the purpose for breakwater, and the best of it yields excellent flagging. When the Independence Stone Company started work in this locality it was about 1,500 feet west of the present quarry. At that place 75 feet of rock were worked without reaching the

base of the formation. The poor quality of the stone caused its abandonment and the opening of the present quarry.

In the year 1869, perhaps a little earlier, the Amherst Stone Company opened a quarry about one-half mile west of Amherst and operated it many years. The Ohio Quarries Company purchased this property in 1907, but the stone proved unsatisfactory, and the plant was abandoned two years later.

Two miles northeast of Amherst is a quarry that was closed or abandoned in 1911. It belongs to the Cleveland Stone Company, and was a large source of grindstones. The formation at the top consists of 12 feet of shell-rock, succeeded by five feet of cross-bedded, which in turn is underlain with an equal thickness of a rotten or shelly variety of stone. The formation at greater depths was concealed by water. The quality of this stone appears unfavorable, and doubtless it was this that closed the quarry. Five gangs of saws were used when the plant was in operation.

Oberlin.—About four and one-half miles northwest of Oberlin is quarry No. 18 of the Cleveland Stone Company, or as it is popularly known, the Kipton Quarry. This plant was opened about 1889 by the landowner, Marshall Schirben, who quarried building and bridge stone, but in 1896 perhaps, he sold the property to the Cleveland Stone Company, who now own almost 200 acres at this place

Section in the "Kipton" Quarry

	Ft.
Glacial drift	3
Berea sandstone.	
Shell-rock. Buff color, with numerous brown iron streaks. Used for ballast and breakwater or thrown on the dump	32
Split-rock. Used for split curbing. Has too many carbonaceous streaks for building stone	30
In places this becomes cross-bedded, and is then shipped to South Amherst or Berea, where it is sawed for grindstones. The refuse material is used as "firestone" in steel plants, and especially at Mingo and Bellaire.	
Spider-web. Good quality for flagging, sills, etc. Contains numerous flakes of white mica. Not quarried in 1913	7½

The quality changes rapidly in this quarry, and consequently the section given above may be correct for one place only. Formerly, all below the shell-rock was used for grindstones, which were made and shipped from this place. These ranged from four feet to six feet eight inches in diameter, but whenever a block of rock well adapted for small grindstones was found it was shipped to Berea, and there sawed and turned into grindstones.

Four or five miles southeast of Oberlin is quarry No. 5 of the Cleve-

land Stone Company, but it is generally known as the Nickel Plate Quarry. It is located on the West Branch of Black River and has been in operation about 30 years.

Section in the "Nickel Plate" Quarry

	Ft.
Glacial drift	15
Berea sandstone.	
Shell-rock. Used for breakwaters	14
Split-rock	10
Liver-rock	18
Split-rock	5
Liver-rock	18
Split-rock	13

The liver-rock is used for corner curbings, building and bridge stone and breakwaters. The split-rock is used for split curbing, but pieces unsuitable for this purpose are turned into small grindstones for farmers. The upper 14 feet are not shell-rock in the usual sense. They may consist of thin layers, but in places they have a thickness of three feet, and are then used for breakwater purposes. The split and liver-rock, which form the base of the quarry, really form one great mass, and are separated by steel wedges. In places the split-rock is entirely replaced with spider-web. The thickness of these courses changes rapidly, and hence the surfaces are not parallel. This quarry is without a sawmill, and the grindstone factory is of the smallest size. About 75 men are usually employed for all purposes at this place. The company owns 285 acres of land, and is, therefore, prepared for many years.

Berlin Heights.—This village, located in the eastern part of Erie County, is the most western place where the Berea sandstone is quarried in Northern Ohio. According to W. G. Burroughs, who has recently mapped the territory for the Geological Survey, the sandstone forms an island, and is surrounded with the underlying shales. The quarry, which is operated by the Baillie Stone Company, is located approximately one mile northeast from the village, and was opened more than 40 years ago.

Section in Quarry of Baillie Stone Company

	Ft.
Glacial drift	3–8
Berea sandstone.	
Shell-rock. Thrown on dump	16
Split-rock. Divided into five courses which range from one and one-half to three and one-half feet in thickness. Used for building stone of all kinds	12½
Spider-web. Sometimes separates into two equal courses. Has many black carbonaceous films. Sawed for curbing and flagging	10
Split-rock	6
Split-rock	4
Split-rock	4

Post Office at Toledo, built of Berea sandstone.

This section was taken in the east end of the quarry, and since the rock varies rapidly in structure, it might not be duplicated elsewhere, or for that matter in the same part of the quarry after a few more feet of stone have been removed. In places there are 12 feet of good buff stone, but in other places none at all. Naturally the buff is found on the high places, but not all such have this color. The horizontal partings are so well developed that the blocks do not have to be split off with steel wedges. The stone is too hard for grindstones and the grit is said to be a little too fine. At present it is used for building stone, flagging and curbing, the latter both sawed and split.

Wakeman.—This quarry is located in Florence Township in the extreme southeastern corner of Erie County. It is four or five miles north of the station Wakeman, which is the shipping point, and from which it was named. The quarry is said to have been opened in 1877 by Nichols and Miller, who got out building stone and some grindstone. When the Cleveland Stone Company was formed in 1886 it became a part of that great corporation. Owing to the absence of railroad connection the quarry has been worked irregularly, the last having been done in the fall of 1912.

Section in the Wakeman Quarry

	Ft.	In.
Glacial drift	2	--
Berea sandstone.		
Shell-rock. Thrown on dump	12–14	--
Shale	--	3
Sandstone	1	--
Shale	--	6
Sandstone	6	--
Shale and shaly sandstone	--	8
Sandstone with iron bands on top. In places the course is divided into three or four	7	6
Contains some concretions, and in places splits into two nearly equal layers	4	--
Shale	--	6
Splits into two nearly equal layers	4	4

Water concealed the base of the quarry. This quarry contains good buff stone, and were it not for that fact it would have been abandoned long ago. Blocks of this lying on the quarry edge measured from one to three and one-half feet in thickness. They were uniform in color, and in all respects a first-class stone. Formerly, the quarry was located on the east bank of the Vermilion River, but the present quarry, which was opened about 1903, is on the west bluff. Absence of railroad connections makes its future problematical.

Grafton.—About one mile southwest of Grafton, on the Baltimore & Ohio Railroad, is Quarry No. 24, of the Cleveland Stone Company.

It is on the East Branch of Black River, in whose bluffs and channel the sandstone under consideration is well shown. The quarry is said to have been opened about 1870, and to have been in operation since that time.

Section in Quarry No. 24, Near Grafton

	Ft.
Glacial drift	21
Berea sandstone.	
Shell-rock. Used for breakwaters, or thrown on dump	2
Liver-rock. Buff color. Used for grindstones	8
In places cross-bedded.	
Liver-rock. Upper seven feet used for grindstones or flagging; lower two feet "flinty" and used for breakwaters or thrown on dump. In places this course is cross-bedded, and contains many coal streaks	9
Liver-rock. Used for grindstones or flagging	4
Liver-rock. Suitable for bridge stone	2
Liver-rock. Used for grindstones or flagging	4

In places the Bedford shales lie directly below the last course of the above section, but elsewhere 10 feet of sandstone are found before the shales are reached. The rock here varies more rapidly in structure than in most places. Hard spots called "flint" are not uncommon, and "cutters" spoil many pieces for grindstone purposes. Formerly, much building and bridge stone were supplied, and the Court House at Elyria was built from this quarry. For a time the supply of buff stone was so large that it was used in bridge work. The mill has six gangs of saws and five lathes for grindstones.

Formerly, a quarry was operated within the Grafton corporation, and the stone sawed for flagging, it being hard and well adapted to that use. There was, however, much waste rock, and the plant was closed about 1905, and the hole which extended to a depth of 180 feet is now filled with water.

Elyria.—Along the northwestern edge of this city is Quarry No. 20, of the Cleveland Stone Company. In this about four feet of buff, coarse, sharp sandstone is worked for grindstone purposes. Formerly, 12 feet of rock were gotten, but owing to changes in the stone the thickness quarried has decreased year by year. This variety of stone is scarce and expensive owing to the amount lost in quarrying. The rock is massive and cross-bedded. Much of it is unsuitable for grindstones and in consequence is used for breakwaters. Saws are not used, and the stone is dressed by hand. About 25 men are employed when they can be gotten.

Ridgeville.—Quarry No. 2 of the Middleburg Stone Company is located about three miles northeast of Ridgeville, Lorain County. It was opened in 1911, and the product is buff stone that is used for

making large grindstones. The glacial drift varies from one to three feet in thickness, and below this lies from four to six feet of the desired buff liver-rock, though in places it changes to the cross-bedded variety. Beneath this is found from two to four feet of shell-rock and then the blue-gray variety, which doubtless continues to the base of the formation. Only the buff stone, which lies immediately below the glacial drift, is quarried. The grindstones vary from four feet in diameter and four inches thick, to seven feet in diameter and 16 inches thick. They are hauled in wagons to Shawville Station on the Lake Shore Railroad. While no building stone is quarried it is not because the stone is unsuitable, but rather because it is more profitable when turned into grindstones.

North Olmsted.—About one mile north of this village the Cleveland Stone Company was opening a quarry in 1913. Only a few feet of rock had been removed, but it was coarse and soft, and of good quality.

Section in North Olmsted Quarry

		Ft.	In.
Glacial drift		2–4	--
Berea sandstone.			
Buff rock.	Used for grindstones	2	6
Shell-rock.	Rejected	--	5
Buff rock.	Used for grindstones	2	--
Shell-rock.	Upper six inches only seen	3	--
Blue rock.	Reported.		

The quarry is without railroad connections, and its future is altogether problematical.

Formerly, the Cleveland Stone Company operated a quarry at Olmsted Falls, but it was abandoned several years ago.

Norwalk.—About two miles northeast of Norwalk the Berea sandstone has been quarried on a very small scale for local use, on the Perrine and Shedd farms, but no work has been done for many years.

Three miles south of Norwalk on the O'Bannon farm is the old Bronson quarry, which has been worked off and on for many years, perhaps a half century. The sandstone outcrops along the bank of a stream, and it was in such a place that the stone was worked. At the top are a few feet of glacial drift, which is underlain with from three to 10 feet of buff shell-rock. Below this is perhaps 12 feet of sandstone which is divided by numerous horizontal cracks or bedding planes, and other fissures cutting across them. The rock, at greater depths reported at from 20 to 40 feet, was concealed by water, but was reported of good quality.

This quarry has been valuable to the community as a source of building and bridge stone, and formerly enjoyed a good market at Norwalk. Quite recently the stone has been crushed and used as a

foundation in road making, but probably it cannot compete with limestone in such work. The stone dips sharply to the south or southeast, and of course this increased the expense of quarrying. The plant never had railroad connections.

Plymouth.—The county line, separating Huron and Richland counties, passes through the middle of this town. On the south side of this line, and on the east bank of the Huron River, a large quantity of Berea sandstone has been quarried. When the place was visited in 1913 the hole was completely filled with water, so that no exposures of the rock were seen. Its principal market was for bridge work, and to a smaller extent for foundations, in the surrounding country. The quarry was without a sawmill or railroad switch. The thickness of stone suitable for the purposes just named is reported to be 30 feet. Use of cement in bridge work, and the increasing amount of stripping in the quarry, were too much, and the plant was abandoned about 1907.

The Berea sandstone is reported to have been quarried to a very small extent on the farm of Elias Eastman on the Huron River, in the northern part of Greenfield Township, Huron County, and on the land of H. J. Willment in the extreme northwest corner of Ripley Township.

Leesville.—This village, which is situated in the northern part of Jefferson Township, Crawford County, has long been a location for quarrying the Berea sandstone. For many years the rock was sawed for flagging and building stone, but about 1908 work was discontinued, and when the place was visited in 1912 the hole was filled with water.

In the latter year a small quarry was in operation along the southern edge of the village, the output being sold for foundation and bridge stone and fence posts. The ledge exposed measured about 25 feet, of which the upper five were shelly, and hence worthless. Below this the beds ranged in thickness from a few inches to two feet, but their thickness varied from place to place. In color the stone ranged from buff or yellow above, sometimes streaked with light brown, to blue-gray below. When visited only two or three men were employed.

This sandstone was formerly quarried for bridge purposes and use among the farmers about two miles southwest of Galion, and near Iberia, in the northern part of Morrow County. The stone has been worked in a more pretentious way about four miles north of Edison, along the "Big Four" Railroad. However, about 1896 the switch was torn up and the quarry abandoned. No mill was built, and the stone was used chiefly for bridge and foundation purposes.

Mt. Gilead.—Just north of this town the Berea sandstone was formerly quarried on the east bank of the Olentangy River. About 20 feet of rock are exposed, of which the upper five to 10 feet are shelly,

but below the layers are heavier, some measuring more than two feet. They are uneven-bedded, and iron concretions were occasionally noticed. The color varies from buff to blue-gray. The general appearance of this stone is unfavorable for building purposes, except for underground work and bridges. The stone is reported to have been quarried also in a small way just south of Mt. Gilead.

Fulton.—This hamlet, located on the Toledo & Ohio Central Railroad, about six miles south of Mt. Gilead, has long been a site for quarrying the Berea sandstone.

Section in Quarry of the Fulton Stone Company

	Ft.
Glacial drift	8–25
Berea sandstone.	
Shell-rock. Uneven beds that range in thickness from an inch to two feet or more. Used for foundation purposes	6–12
Massive rock. Without real bedding planes. Sawed for flagging, curbing and building stone	27
Bedford shales.	

In general structure the Berea sandstone at this place is much like that farther north. Vertical breaks are not common, neither are there well-marked bedding planes. The horizontal cracks appear and disappear, but none seem to be continuous over the quarry. In places these cracks amply separate the layers to meet the needs of the workmen, but not infrequently steel wedges have to be relied on. Quite often the surfaces of fracture are decidedly uneven.

The stone is a little finer in grain than that farther north, and perhaps a little harder. Where unweathered the color is blue-gray. Concretions are not common, but on weathering iron spots occasionally appear. An analysis of the sandstone may be found on page 74.

In places bedding lines are fairly distinct, but more commonly the structure is homogeneous, like liver-rock. Of special interest to the geologist are sandstone pebbles, occasionally found in the formation. These are well rounded, but have no definite shape or size. The largest seen measured three and one-half inches in diameter. They have a gritty feel, but are usually a shade darker than the body of the sandstone. They may occur singly, or be so abundant as to comprise a large part of the rock, but illustrations of the latter are uncommon. While they are not limited to any section of the stone they are reported most abundant from six to 15 feet above the base of the formation. They mar the stone for all purposes, except for bridge and underground work. The only plausible explanation of their origin is that they represent fragments from adjacent parts of the sandstone that were rounded by waves and then buried in sand.

The rock from this quarry is sawed for flagging, curbing and build-

ing stone. · Formerly it was split for curbing, but the stone now quarried, except in small part, would not permit of such work. The stone breaks as well in one direction as another. Three gangs of saws are kept busy. Crushed steel and lake sand do the work, and lime prevents the iron discoloring the rock. While the market is largely at Bucyrus, Columbus, Marysville, and other points along the Toledo and Ohio Central Railroad, it has been shipped to Iowa and other distant points. The company employs from 35 to 40 men when they can be gotten, and saws about 75,000 cubic feet of stone per year.

When work was first begun in this locality is not known, but it was probably half a century ago. For many years quarrying was done by hand labor, but about 1890 power was introduced. In 1897 saws began working and this increased the market for the output.

Formerly, there were two additional quarries in this vicinity, but both were abandoned years ago. Neither had a mill, and probably their product was largely for bridge and foundation purposes.

Sunbury.—This village, located in the southeastern part of Delaware County, was for many years an important place for quarrying the Berea sandstone. The rock is exposed in the bed and bluffs of Big Walnut Creek, and its principal tributary, Rattlesnake Creek, and along both streams the quarrying industry flourished.

The upper 18 feet consist of shell-rock, whose best courses were dressed for curbing, and occasionally for flagging and foundation purposes. Below this lay about 12 feet, in beds of from eight inches to three feet, which were usually sawed for flagging and building purposes. No stone was ever sawed in this locality, however, for curbings, and it was considered too hard and fine-grained for grindstones. The stone varied much in constitution from place to place. Occasionally it is decidedly concretionary, and then of course worthless for structural work. This character has led quarrymen to speak of the good rock as occurring in pockets. Concretions and "hard-heads" were not common, but occasionally the rock on exposure developed iron streaks. The last quarrying was reported to have been done in 1910.

The Sunbury Stone Company was perhaps the largest organization at work in this locality. For years quarrying was on a small scale, but later a railroad switch was built and a sawmill erected. This was operated approximately 18 years, but could not compete with cement, and so was abandoned about 1896. A short distance down stream, where the railroad crosses Big Walnut, were formerly two quarries. The plant up stream from the bridge was operated a few years by Westwater of Columbus, but the results were not satisfactory and the mill was moved to Reynoldsburg. Just below the railroad bridge was the Flechner quarry. The stone was not sawed but was shipped in large

pieces and enjoyed a good market. It closed about 1903. Much of the stone used in building the Cleveland, Akron & Columbus Railroad, was obtained from these quarries.

About one mile east of Sunbury the stone was quarried along Rattlesnake Creek by Williams, who supplied a natural flagging and curbing. In addition he quarried stone for monument purposes, which he hauled in large part to Delaware, 13 miles distant. At least one additional quarry was located in this vicinity, but all work along this

Fig. 4.—Entire section of Berea sandstone near Lithopolis. Note unconformity between sandstone and underlying Bedford shale. Photograph by H. A. Gleason.

stream was abandoned many years ago. Should market conditions ever warrant it, Sunbury might again become an important place for quarrying the Berea sandstone.

Gahanna.—Along Rocky Fork, near the village Gahanna, a few pieces of the Berea sandstone are still quarried occasionally, and there is evidence that the stone was formerly worked in a slightly larger way. A few miles farther north, near the village Harlem, the rock has been worked within the past few years for road making, but it is not well adapted to this purpose. At that place the rock is shelly, and hence not well suited for building stone.

Waverly.—This town was for many years the center of the Berea sandstone industry in Southern Ohio. When quarrying began was not learned, but the canal was built about 1832, and furnished both power to saw the stone and shipping facilities to Columbus and other

places. Probably quarrying of the Berea sandstone began about the time the canal was completed. From that early date work continued on a large or small scale until 1912, when the last of the quarries was abandoned.

The quarries were located along the bluffs of the Scioto Valley and its tributaries, from the vicinity of Waverly south to Jasper. For a general description of the formation use is made of the work of Dr. Orton:[1]

"The greatest thickness found in this division (Berea) is 32½ feet. This measurement was made in a closed section one mile south of the village of Jasper * * *. From Jasper to Waverly, where the typical quarries of the system occur, the thickness never reaches these figures, because of the fact that the system as it is here shown is in no case entirely complete. Its upper beds have been removed by denudation. At Jasper the quarry beds measure twenty-five feet, and at Waverly they do not fall below twenty feet. The quarry courses thin out, however, rapidly to the north and east. At Marcus Run, on the east side of the river, three miles above Waverly, there is a fine exhibition of a closed section of the quarry courses in which they measure less than ten feet. On the western side of the county, also, not only is the thickness reduced, but the character of the courses is changed. They consist to a much greater degree of thin and 'shelly' layers than in the central districts above described. At Jasper and Waverly the lowermost course of the system is generally one of the most valuable, but on the east side of the river at the locality just mentioned, the lower course is worthless, and the only available bed lies just at the summit of the system. Many courses that in the quarry appear desirable, prove unreliable when exposed to the weather. Serious loss results if there is a lack of knowledge or of conscience on the part of the quarryman in the selection of the proper courses. Experience alone can determine the character of the several beds, and it is not safe to apply conclusions drawn from one element of the series at a particular point to the same element at another point. The most valuable courses in the quarry pass sometimes quite abruptly into a very rough and ungainly stone, called 'Turtle-back' or 'Nigger-head' by the quarrymen * * *. Such courses are altogether valueless as building stone, and are used only for the protection of river banks and for other similar purposes. The large amount of waste material to be moved in reaching the most reliable and desirable courses constitutes the main element in the expense of quarrying. In the Jasper quarries, for example, not more than ten feet of the thirty feet that belong to the system can be put into the market as first-class building stone.

"Of the many shades of color displayed by the Waverly quarry courses, perhaps a light drab can be taken as the standard; at least it is the color which is most highly esteemed for architectural purposes. It is not, however, an original color of the stone, but has been formed by the action of the atmosphere on the external portion of the exposed layers. The native color of the beds from which this most approved variety is derived is a delicate blue—a little deeper than the shade known among painters as French-gray. By the oxidation of some of its materials, or possibly, by the removal in solution of a small portion of oxide of iron, the change is effected * * *.

"The change from the blue color to the lighter tint has taken place in all exposed portions of the rock, but seldom extends inward more than ten or twelve feet. As these weathered portions have been first removed, not only on account of the desirability in color, but also by reason of their greater accessibility, it has come to pass in all of the larger quarries that the supply of the first variety is much more limited than

[1]Geol. Surv. of Ohio, Vol. II, p. 621.

formerly. The blue stone when laid in masonry undergoes a change of color in its exposed portions, similar in kind to that which the outer portions of the native beds have already passed through.

"There is also in the Waverly system a large amount of stone of a yellowish cast, which deepens by exposure; but this, though equally durable, is less sought for the better class of buildings."

Apparently none of the quarries attained great proportions, probably due to the heavy stripping as work extended into the hill. One of the largest was the Stevens on Pee-pee Creek, which was opened about 1870, and is reported to have closed ten years later. The stone was hauled in wagons to Waverly, where it was sawed, and then shipped by canal. Following is a section of the Berea sandstone in the old Peck quarry, about four miles northwest of Waverly:

	Ft.	In.
Lense-shaped beds. May be worked in places	2	--
Bed with uneven surfaces in places	1	4
Shaly sandstone	--	6
Sandstone	--	7
Shaly sandstone	--	1
Sandstone	--	11
Shaly sandstone	--	6
Sandstone, upper six inches shaly	1	3
Shaly sandstone	--	6
Sandstone, lower five inches shaly	1	8
Shaly sandstone	--	6
Massive bed of sandstone. Upper surface ripple marked. May split into two or more layers. Shaly in places	2	6
Sandstone and shaly sandstone. Layers uneven and generally worthless	6	--
Base of quarry concealed.		

The quarry was located near the top of a hill, about 90 feet above the valley of Crooked Creek. Stripping amounted usually to less than twenty feet, but much of the rock quarried had to be rejected. The company used steam drills and had a sawmill with two gangs of saws. The stone is medium in grain and the color buff, mottled or banded. It was used chiefly for bridges, and to a small extent for curbing, flagging and architectural purposes. This quarry was opened about 1892 by the Waverly Stone Company, which failed in a few years, and little or no quarrying has been done since 1902. The mill was the last one for sawing stone in Pike County.

About one and one-half miles down the valley of Crooked Creek from Peck is the old Sosco quarry, on the Detroit, Toledo & Ironton Railroad. From 25 to 30 feet of sandstone are exposed, and above it about two feet of Sunbury shales. Most of the stone is of poor quality, and hence there is much waste in quarrying. The stone is

broken, and while some of it is even-bedded, much of it is the reverse. The layers vary from a few inches to two feet in thickness. The unweathered stone has a pronounced blue color and the weathered part a buff. Some layers are charged with iron and have a brown color. The stone was used largely for railroad purposes. This quarry was opened about 1882 and was worked approximately 30 years.

Piketon.—A quarry in the Berea sandstone was opened many years ago on the top of a hill at Piketon. It was operated on a small scale,

Fig. 5.—Partial view of Berea sandstone in old Peck quarry near Waverly.

but was abandoned perhaps 25 years ago. Following is a section in this quarry:

	Ft.	In.
Sunbury shales	20	--
Berea sandstone.		
Sandstone, buff to brown. Splits into irregular layers	6	6
Sandstone, shelly on top	1	3
Sandstone, gray to buff. Broken in places	2	--
Sandstone, shelly on top and with ripple marks	1	1
Sandstone, shelly on top	--	9
Sandstone, shelly on top. Buff color, but streaked on top with brown	2	--
Sandstone, shaly	--	4
Sandstone	1	7
Shales	--	3
Sandstone	--	11
Shales	--	2
Sandstone	--	9
Shales	--	2
Sandstone	1	6

The layers in this quarry, except the top six feet, are quite regular, and nearly always separated by from one to four inches of shales. The rock is not much broken nor is the concretionary structure prominent. The stone had a large market on the Norfolk & Western Railway which used it for bridges.

Near Cyanthiana, in the northwestern part of Pike County, the Berea sandstone lies at or near the top of the hills, and varies from red-brown, red and gray-banded, to gray and blue-gray in color. The

Fig. 6.—Berea sandstone in old Wellman quarry, Henley, Scioto County. Photograph by J. E. Hyde.

red is found only in the top layers, and varies from one inch to two feet in thickness. This color is not always fast and hence may stain walls below. The banded variety is about as abundant as the red-brown, and both exist in commercial quantity, though not in a large sense. Gray and blue-gray are, of course, the common varieties. This stone was formerly quarried in an irregular way and hauled in wagons as far as Wilmington. For these facts the Survey is indebted to Mr. Wylie Austin.

McDermott.—The Berea sandstone, with a few feet of the overlying Sunbury shale, is well shown in the railroad cut at the west end of this village. In thickness the beds of sandstone vary from a few inches to four feet, and the intervening beds of shale attain a maximum thickness of 21 inches. A few of the layers of sandstone are regular, but those near the top are notably irregular and concretionary. While some good stone might be gotten at this place the quantity of waste would be very large, and the project a financial failure. The Berea may

be seen in the bed of Scioto Brush Creek, less than two miles below McDermott, and J. S. Smith, President of the McDermott Stone Company, states that it forms the bed of the Scioto River just above the mouth of Scioto Brush Creek.

Buena Vista.—This village, situated on the bank of the Ohio River in the southwestern corner of Scioto County, was for many years one of the important quarry centers of Ohio. As stated elsewhere, the sandstones of the Cuyahoga formation were the source of the stone quarried, but according to the late Professor E. B. Andrews the Berea is also there in good quality. His section follows:[1]

	Ft.	In.
Berea sandstone and interbedded shales.		
Sandstone	1	8
Shales	4	3
Sandstone	2	3
Shales	2	6
Sandstone	1	9
Shales	2	9
Sandstone	1	8
Shales	1	3
Sandstone	3	6
Shales	1	6
Sandstone	1	4

According to Professor Andrews the base of the Berea is 175 feet above the valley of the Ohio River. Though the formation has never been worked there, at any rate not on a commercial basis, Professor Andrews considered it of excellent quality, and wrote, "Those layers (i. e., the Berea sandstone), below the 'City Ledge' are many of them very thick and of great fineness and firmness of structure, and almost indistinguishable from the stone of the 'City Ledge.' There are many places where the lower stone (Berea) could be moved to advantage."

Overlying the Berea are 21 feet four inches of Sunbury shales, and above these in turn the famous City Ledge, whose thickness and properties are described on a subsequent page.

Apparently the Berea in this locality contains a large quantity of good stone that has never been quarried because of the presence of the City Ledge, which early attained a splendid name in the market.

Quarrying of Berea Sandstone, and Preparing it for Market

In early days the Berea sandstone was quarried at the surface of the formation only. The layers were thin, and were broken to

[1]From a report dated July 20, 1872, on the value of the building stone in the vicinity of Buena Vista. Published privately.

desired size by means of steel wedges. If the layers were not of the proper thickness, they were split. The demand for stone was small, so that primitive methods of work gave an adequate supply.

With the growth of the industry it was found necessary to work at greater depth and in thicker courses. When a given area had been stripped of glacial drift, shales or shell-rock, it was necessary to de-

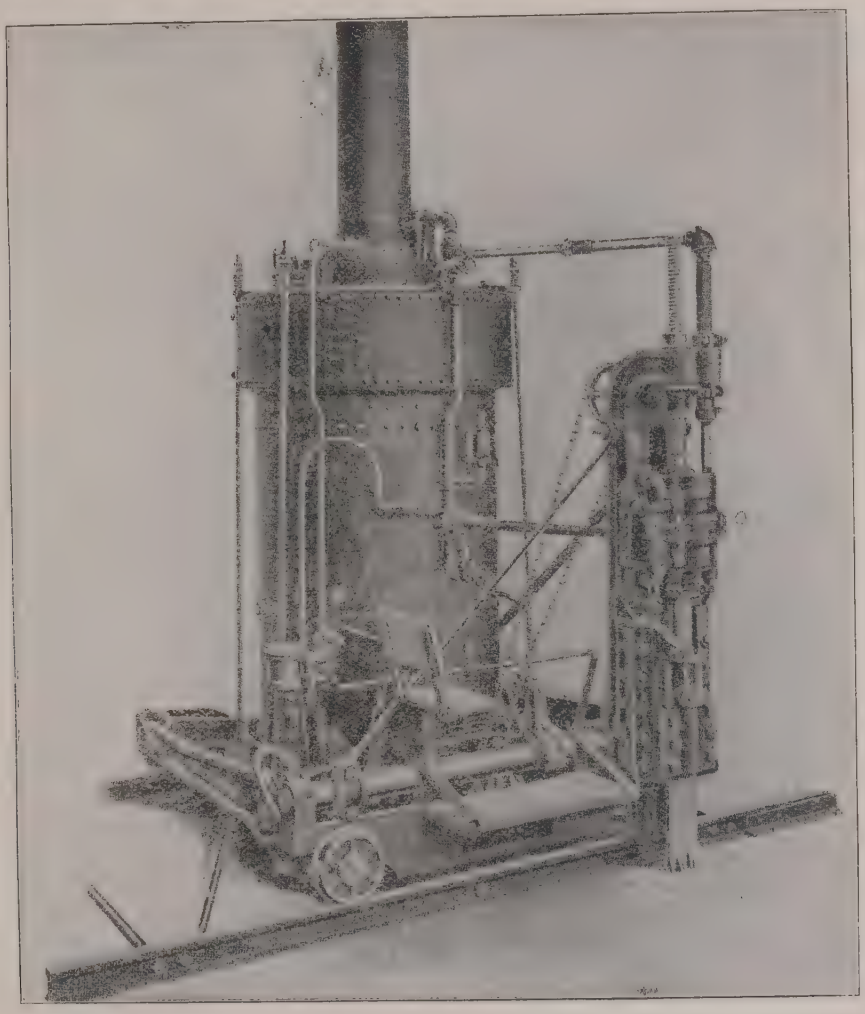


Fig. 7.—Channeling machine used in quarrying Berea sandstone.

tach the area from the surrounding rock. This was done by quarrymen who cut channels or trenches with picks in two directions at right angles to each other along the borders, the width of the channels being sufficient, of course, to admit the body of the workman. Not only was this slow work, and in summer very hot, but the dust produced attacked the lungs and throat of the workman, sometimes with fatal results. When the trenches were cut to the desired length and width, and the area of stone thus freed in two directions, drilling and blasting were resorted to, and blocks of the desired size obtained.

Channeling Machines.—About 1880 channeling machines were introduced, and soon displaced the old method of trenching or channeling by hand. This machine is essentially a small locomotive that moves slowly forward and backward on steel rails. The cutting or channeling is done by chisel-like tools, whose width along the cutting surface usually varies from two to five inches. These tools are three in number, two of which are placed at right angles to the trench to be cut, while the third is between and diagonal to the two. Finally the three tools are gripped together so that they act as a unit. The engine or locomotive drives these tools in a vertical plane, and their impact on the rock cuts it, forming a trench or channel, which of course, varies with the width of the tools, that is from two to five inches. Naturally the stone dulls the cutting edge, and wears away the sides of the tools, narrowing them. For this reason the channel is widest at the top and narrowest at the bottom. As the tools are worn they are replaced with narrower ones, and generally this has to be done for each foot of depth, but this depends upon the nature of the stone, the quality of steel and the length of the channel. The usual depth of channeling varies from seven to 10 feet but may reach 16 feet. By means of these machines the rock is cut in retangular blocks, whose size depends on the nature of the stone and the use to which it is to be put.

Drilling and Breaking—Drilling is done by steam power, and the holes are cut rapidly and with small expense. There are two ways of breaking the stone, by powder and by wedges. The larger blocks are usually broken by powder, and when these in turn are to be further reduced in size it may be by powder or wedges. Powder discolors the surface, and is therefore objectionable for building stone. Moreover, the direction of fracture cannot be so well controlled, and there is a tendency to shatter the stone. For these reasons much breaking is done with wedges. If the rock is to be broken with powder the holes are first reamed, that is, a small V-shaped notch is made on each side of the hole, in the direction the rock is to be broken, by driving into the hole a steel rod with an angular projection on each side. The notches seem to direct the force of the explosion, and thus the direction of breaking.

If the stone is not to be broken with powder, holes of from one and one-eighth to two and one-half inches in diameter are drilled, and then steel wedges driven into them. These wedges consist of three parts, a central piece known as a plug, which is simply a long tapering steel wedge; and two steel strips which thicken below, are flat on the inside and convex on the outside, and known as feathers. The "plug" is driven between the "feathers," and because of the varying thickness of the pieces the pressure is fairly evenly distributed and regularity in breaking assured.

With the exception of the quarry at Grafton, the Berea sandstone in northern Ohio is everywhere reported to have a right and wrong direction of breaking, or as the quarrymen express it, a "breaking and rolling way." When broken in the right direction the surface of fracture is fairly even and at a right angle to the bedding plane, but when in the wrong direction it is not at right angles to the bedding plane, and the surface of fracture is rolling. In some places the "breaking way" is indicated on the bedding plane by long shallow depressions,

Fig. 8.—Sawing Berea sandstone.

but in most places this is not true. From Berea to Berlin Heights the right way of breaking is nearly east and west, that is, parallel to the old shore line.

Splitting.—As has already been stated, bedding planes in the Berea sandstone are uncommon, and in fact generally absent in Northern Ohio. Horizontal cracks of short extent, however, are common, and in quarrying may take the place of bedding planes. Generally, however, the seperation is not complete, and then quarrymen drive a row of short steel wedges into the crack and thus complete the separation. If no horizontal crack is present, quarrymen split the stone by driving the wedges where the fracture is desired. When the stone has been broken into blocks of the desired size, they are removed from the quarry by huge derricks, operated by steam or electricity.

Preparing the Stone for Market

After the stone has been broken to rectangular blocks its subsequent treatment depends on the nature of the stone and the use to which

it is to be put. A small proportion is marketed in the rough for foundations and bridge work, more is split and marketed in that form for curbing, but the greater part of the rock is sawed.

Sawing.—Much of the Berea sandstone is sawed before marketing. This is done with flat strips of steel from one-eighth to three-sixteenths of an inch in thickness and about 17 feet in length. As is well known the cutting edge of these saws is smooth, quite unlike those for wood or metal. They are fastened in a rectangular frame, which moves back and forth, and thus drags the saws over the stone. The number of saws to a frame varies greatly, depending on the size of the block of stone and the number of pieces into which it is to be cut, but it usually

Fig. 9.—Turning a column of Berea sandstone.
Courtesy of Ohio Quarries Co.

ranges between eight and 20. The actual cutting is done chiefly by sand or small pieces of steel, which are fed to the saws with a liberal supply of water, the solid material being used over and over. The steel is of two types, roughly spherical like bird-shot and angular. The latter is known as crushed steel, and is the more extensively used. Likewise two types of sand are used, one a coarse, clean "silica sand," whose chief source at present is Ottawa, Illinois, and the other a lake sand which has a finer texture, and in most cases is less efficient. Sand alone may be used, but much more commonly sand and steel. The latter gives a rough surface to the stone which is objectionable for building purposes, and hence the use to which the stone is to be put determines in part the method of sawing. As might be expected the steel discolors the stone, and this difficulty is met by adding lime.

Planers.—Part of the stone used for building purposes, and much of it for curbings, is planed before shipment, so that but little remains to be done to it. The stone is first broken or split to the approximate

size desired, and is then placed on the planing machine. The cutting is by a steel tool whose edge is flat or curved, depending on the surface desired. Against this tool the stone is forced, and its surface cut of scraped off. Planing of curbing has long been done, but the finishing of moulding by planers in this locality dates from about 1908. In this type of work one planer is said to do the work of six men.

A more recent use of machinery is in making columns. After the rectangular block of stone has been delivered to the mill the corners are knocked off with hammers and the block then placed on the lathe. As the stone is rotated the projections on its surface are reduced by a steel tool less than a quarter of an inch wide, and bent up at the cutting edge. This tool is then replaced with one somewhat oval at the end and the surface of the stone gone over again, which further reduces the inequalities. Finally a flat chisel-like tool with a straight edge is placed on the lathe, and once more the surface of the column is cut away, leaving a smooth, even surface. This machine, the property of the Ohio Quarries Company, which does the work of many stone cutters, was installed a few years ago.

The Ohio Quarries Company also has devised a machine for putting a "tooled surface" on sandstone. This consists of a carborundum wheel 10 inches in diameter and 12 inches wide, which is made up of 56 thin wheels, clamped together with slips of paper between them. The edge of each of these constituent wheels is convex, so that as the flat surface of stone is forced under the wheel it is given a "tooled surface."

The same company also uses a "rubbing-bed" in preparing building stone to meet the market calls. This "bed" is a steel wheel 14 feet in diameter, which rotates in a horizontal plane. "Silica sand" and water run over the surface of the wheel, so that when a block of stone is laid on it the surface is worn flat and smooth.

Use of the Berea Sandstone

The Berea sandstone is used for nearly all purposes that a sandstone is. Chief of these are building, flagging, curbing, bridge, grindstone, whetstone, breakwater, ballast and road making.

Building Stone.—Many people think of the Berea sandstone as a building stone only, and this idea is the result of the stone's very wide use for this purpose. During the last three-quarters of a century it has been a great favorite from New York to Chicago, and it deserves all the praise that has been bestowed on it. In fact it is easily the leading light colored sandstone for building purposes in the United States.

The stone possesses all or nearly all the qualities demanded of a first-class stone. For 75 years, perhaps more, it has been on trial in the worst climate to which building stone is subjected, and it has fully

met the requirements. Like all stone it yields slowly to the weather, but where the Berea is carefully selected and properly laid it will doubtless last for centuries, and that is as much as is demanded of any building stone. It is cemented with silica which is highly insoluble, and for that reason the cement is not leached out leaving a friable mass. Temperature changes, including freezing of water, do the minimum amount of damage, so little in fact that architects and engineers scarcely think of it.

The color of the stone is a uniform light blue-gray, except near the surface where it has weathered to gray or buff. The quantity having the latter color, however, is so small that it plays little part. The blue-gray stone on exposure loses its blue tint and becomes a gray or light buff, the former being much the more common, and the change being uniform, except where concretionary masses of iron are present which weather to a pronounced brown. Formerly quarrymen were not care-

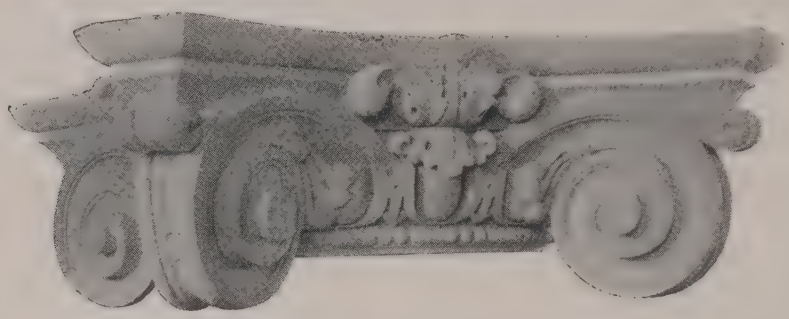


Fig. 10.—A carved block of Berea sandstone.
Courtesy of Ohio Quarries Co.

ful to reject such pieces and they bear testimony against the stone to this day. Largely on account of these concretionary masses but little stone from Berea is now marketed for building purposes, the supply being obtained from South Amherst, and to a subordinate extent from Columbia Station. In fact nearly every quarry contributes some.

The strength of the stone, both crushing and transverse, as shown on preceding pages, is high and adequate for all existing needs. It cuts well, and few stones are better adapted to carving.

Whether finished with a smooth or rough surface the stone make. a handsome wall, while for trimming brick structures it has no superiors It resists abrasion and is, therefore, admirably suited for steps and walks.

The stone has had an extensive market for building purposes from Boston to the Mississippi River, with numerous sales in more remote places. It may be seen in the walls of thousands of buildings, and to name them, therefore, is out of the question. Among the important structures of Berea sandstone may be mentioned the Postoffices of Toledo and Columbus; the Library of Cornell University; Masonic Temple, Minneapolis; South High School and Ohio National Guard

Armory, Cleveland; Court House, South Bend, Ind.; Court House, Detroit, Mich.; Canadian Bank of Commerce, Winnipeg; Merchants Bank of Canada, Montreal; Dominion Postoffice, Toronto; John Hancock Life Insurance Company, Boston; Presbyterian Church, 57th Street and Madison Avenue, New York; St. Marks Church, Washington D. C.; Federal Building, Hot Springs, Ark.; Electrical Building, State University, Lawrence, Kansas; Teutonia Insurance Company, New Orleans; Soldiers and Sailors Memorial Hall, Pittsburgh. Nearly every city and town in Ohio has one or more illustrations of the stone, and many of the court houses are built of it.

During the past 20 years the market for Berea sandstone for building purposes has not grown for several reasons. The attractive shapes, surfaces and colors of bricks have led to their use in structures, large and small, where formerly stone was more generally used. Indiana limestone has increased greatly in popularity, and many architects specify it rather than the Berea sandstone. The third cause is Portland cement, whose use has gone forward with leaps and bounds, often supplying material for foundations, and occasionally for steps, sills, caps and entire walls.

Flagging.—As has already been stated this stone is first-class for flagging. It has the necessary strength to permit being sawed into thin slabs, resists temperature changes, and gives way slowly under the abrasion of men's shoes. Occasionally a block of poor stone is worked into flagging and it may go to pieces, or develop large brown spots that are unsightly. Not infrequently such patches shell off in curved layers and this makes the surface uneven. It must be borne in mind, however, that such phenomena appear only when an inferior grade of stone is used. The thickness and area of the flagging varies from two to four inches, but occasionally it is six, while the area may attain 128 square feet. Flagging is always sawed along the bedding plane except when the structure is cross-grained, and it is then impossible. Quarrymen report as much flagging gotten out as there was 20 years ago, notwithstanding the competition of cement. Were it not for cement, however, the demand for flagging would be several times larger than at present.

Curbing.—No other stone in the United States is so extensively used for curbing as the Berea sandstone. There is no standard size for this purpose, and the dimensions are determined by the orders received. Usually the length varies from four to eight feet; the width from four to eight inches, and the height from 12 to 30 inches.

Two types of curbing are made from the Berea sandstone, the split and the sawed. For the split the stone is obtained in large blocks, lifted from the quarry, and then broken into rectangular blocks of sufficient width to give the desired number of pieces. These blocks are then loaded edge up on flat cars, and split into slabs with steel

wedges. Occasionally the stone is marketed in this form and finished by stonecutters where the curbing is used. Much more commonly, however, it is put on the planers and finished before shipment. The plan of a planer is very simple and may be readily understood. The cutting is done by steel-like chisels against which the stone is forced. These chisels are five in number, four of which are narrow and have a straight edge, while the fifth has a notched edge and is four inches wide. The stone is gripped on the bed of the planer and is then forced against the tools which are inclined forward ready, so to speak, to meet the stone. First the narrow tools known as "diggers" are forced across the stone, the notched tool doing nothing. Next the tools, which are gripped together, are moved to the right so that the "diggers" meet a strip of stone heretofore untouched, and the notched tool passes over the strip recently gone over by the "diggers." This process is repeated until the portion of the stone that is to project above ground has been planed. The notched tool leaves a surface of parallel ridges which improves the appearance. The stone is then turned over and the other side planed in the same way. Finally, what is to be the upper edge of the curbing is planed with a concave tool with a notched edge, so that it leaves a convex surface on the stone. When the planer has cut across the stone, the beam or "head" which grips the tools turns automatically at an angle of 90 degrees, so that as the stone is carried back it is planed just as it was when moved forward.

When the stone will not split with parallel surfaces it is sawed to the desired thickness and of sufficient height for two pieces of curbing. It is then loaded on flat cars and broken with sledges. The rough surfaces of fracture are later smoothed by stonecutters where the curbing is used. Rarely curbing is sawed on four sides to meet special demands.

Grindstones.—From the beginning of the stone industry in Northern Ohio the manufacture of grindstones has been important. As their quality became known the market extended, and the formation has long been the principal source of grindstones in the United States. In fact about 85 per cent of the total production is derived from the Berea sandstone of Ohio. The market has long extended beyond the confines of the United States, and now includes Russia and many other European countries, South America, Cuba, the Philippines and Japan.

As stated elsewhere, John Baldwin was a pioneer in this industry, and finding cutting them out by hand too tedious to meet the growing market, he devised a more rapid method of work. Taking a piece of wood, in 1833, to a lathe in his neighborhood, he shaped it to the desired form as a pattern, and then carried it to Cleveland where he had a metal cast made of it. Returning with this to his home he fastened it to the end of a water wheel, and then cutting a hole in a slab of stone he

fastened it to the rotating shaft. Then holding a metal rod at the side of the stone the exterior was cut off and a grindstone remained. This was the first grindstone ever cut by machinery in the west, and from what follows it will be seen that the method has been but little improved on.

With occasional exceptions to be noted later, the stone is sawed to the desired thickness, and then broken into squares of the approximate size of the grindstone desired. Next a hole is cut through the center of the slab for the axle. This is done in one of two ways, most commonly with a pick, the hole being square, or with a rotating drill, in which case the hole is circular. This done the stone is fastened on

Fig. 11.—Turning a grindstone from Berea sandstone.
Courtesy of Ohio Quarries Co.

a rotating shaft preparatory to giving it a circular shape and truing it. The first is accomplished by holding against the side of the rotating slab, and as far from the center as may be, a soft steel bar whose end is sharply bent. This cuts a circular trench in the stone and the process is then repeated on the opposite side. When the trench has reached the necessary depth, the part of the stone outside of it flies off leaving a circular piece behind. The surface of the rotating stone is next smoothed and the sides trued with the same tool, when it is ready for mounting and use. In making very large grindstones the corners of the block are first knocked off giving it a rudely circular shape. The block is then sawed into slabs of the desired thickness, rounded, and square holes cut through them with picks. Finally they are placed on the rotating shaft and finished in the same manner as the small grindstone. Occasionally slabs of stone are quarried that are too thin for sawing; these have their surfaces smoothed with picks, are rounded with the same tool and finished as other stones.

The size of grindstones made from the Berea varies greatly, depending on the use to which they are to be put. Their diameter ranges from a few inches to seven feet, perhaps more, and their thickness from two or three inches to 16, rarely larger.

The requisites for a good grindstone are simply a clean, sharp sand, free from clay or other impurities. The grains need to be strongly cemented together, but when this condition is reached any further cement is objectionable, since it reduces the grit. The coarser the stone the faster the cutting. Hence for certain kinds of work a coarse sand is required and large grindstones are made, while for others a fine sand is necessary and the grindstones are smaller. The sandstone at Berea is of finer grain than that farther west, and this locality is therefore the main source of the small grindstones. Larger grindstones are produced at nearly every other point in Northern Ohio where the Berea sandstone is quarried.

In making scythe stones the rock is first sawed to thin slabs and then broken to rectangular pieces of the desired size. The corners and edges of these are ground off on a "rubber," which is a horizontal wooden wheel over four feet in diameter whose upper surface is well covered with steel clippings that have been driven in the wood. Sand and water are poured on this rotating wheel and the scythe stones are soon given the desired shape.

Other Uses.—The poorer parts of the Berea sandstone have an extensive market for breakwaters. The stone is used also in a small way for lining furnaces, for concrete, for road making and occasionally for still other purposes. Under cover in Southeastern Ohio the formation is an important source of oil and gas.[1]

THE SANDSTONES OF THE CUYAHOGA FORMATION

The Cuyahoga formation, which lies above the Berea sandstone, from which it is separated by the Sunbury shale, forms a broad strip that extends from the Pennsylvania state line west to the longitude of Norwalk, and thence south to the Ohio River. Its thickness in northeastern Ohio, according to Professor Prosser, varies from 100 to 300 feet; in Eastern Licking County, Professor J. E. Hyde reports it 588 feet, while in the southern part of the State he found it ranging from 625 feet in central Hocking County to 250 in western Scioto. Naturally a group of rocks of such thickness forms a broad area of outcrop, especially where the topography is comparatively smooth as in the northern half of the State.

The rocks of the Cuyahoga formation consist of shales and sandstones which as yet have had but little commercial value. The shales

[1]Bownocker, J. A., Geol. Surv. of Ohio, Bull. 1.

are now used for making brick at Portsmouth and the product has an excellent reputation. Doubtless shales of this age can be used in other parts of the State for similar purposes. It is the sandstones, however, that have attracted most attention and have been most extensively worked. While the principal quarries have been at the two extremes of the State, that is, in Trumbull and Scioto counties, the stone has been worked at a few other locations, though on a small scale.

At the request of the writer, Professor Hyde, who has made a detailed study of the Cuyahoga formation in Southern Ohio, has prepared the following paragraphs on the geological relationships of the building stones of the formation in that part of the State.

The Geological Relationships of the Cuyahoga Building Stones of Central and Southern Ohio

"The Cuyahoga formation is an exceedingly variable one in Central and Southern Ohio. It is usually thought of as a shale formation but in places it is largely made up of sandstone. Along both sides of the Scioto Valley from Chillicothe to Portsmouth it is largely a shale about 300 feet in thickness.

"Northeast of this shale area, the Scioto Valley shale facies, lies a tract in which the Cuyahoga is almost wholly made up of sandstone and conglomerate. This is best developed in Fairfield and Hocking counties where the massive, coarse sandstones and conglomerates give rise to cliffs, which are the most striking feature in the scenery of one of the picturesque portions of Ohio. In the center of this Hocking Valley conglomerate facies, the Cuyahoga attains a thickness of 625 feet, as shown by wells which penetrate to its base. For various reasons the upper 100 feet, more or less, of this sandstone is distinguished as the Black Hand member. This member has been quarried at many points from Lancaster south to Logan, and at two localities the industry has attained considerable importance in the past, although there has been a marked decline in late years. At Lancaster, and at points in the northwestern part of Fairfield County, several small openings have been made in the sandstone of the middle portion of the Cuyahoga, and hence below the Black Hand member. One of these, the Keen and Sieber quarry at Lancaster, is yet working, and supplies the demand for stone for general constructional purposes in the vicinity. In the northwest part of Fairfield County the basal portion of the Hocking Valley sandstone facies comes to the surface and is excellently shown at Lithopolis. The lowermost 100 feet, more or less, of the Cuyahoga here consists of regularly alternating sandstones of finer grain and shales; two of these beds have been the source of the stone which was exploited for many years in the Leyendecker quarry at that village. The sandstones in the lower part of the Cuyahoga, which have been worked near Reynoldsburg, in the eastern part of Franklin County, are of precisely the same type as those seen at Lithopolis, and are best interpreted as the basal and only remaining portion of the northward extension of the Hocking Valley conglomerate facies, from which the main thickness of conglomerate and sandstone has been removed by prolonged erosion.

"The coarse sandstones of the Hocking Valley facies pass rather abruptly, but by lateral graduation into the shales which make up the Cuyahoga to the westward. Many sandstones in thin and regular beds are continued out into the Scioto Valley shale area as far as the Scioto River and even beyond. These are hard and finer-grained than the massive sandstones of the Hocking Valley, yet they feel peculiarly harsh to the touch. They are characterized by their reddish-brown color on the outcrop, due to considerable iron cement. The Gregg stone, formerly quarried in a small way

east of Waverly under the name Waverly brown stone, and described by Orton as a very promising stone,[1] lies only a few feet above the base of the Cuyahoga and is of this general type.

"West of the Scioto Valley shale facies lies another area in which sandstones make up a very large precentage of the Cuyahoga. The thickness is there reduced to about 250 feet. The name Vanceburg sandstone facies is given to this area from Vanceburg, Kentucky, a few miles below Buena Vista, where it is typically developed and well exposed. This facies is developed in the western portions of Scioto and Pike counties, and extends into Adams County, but it barely touches the southwest corner of Ross County. The Cuyahoga there consists of regularly alternating beds of sandstone and shale, the sandstone of a type wholly different from those found in the Hocking Valley area. The beds are strikingly regular, but the great majority of them are one foot or less in thickness. There are many, however, that are of good workable thickness, and some of these have been and are now exceedingly valuable. Many of the shale beds are mere partings, sufficient to greatly facilitate, and in no way hinder quarrying, and it was the succession of some 12 or 15 sandstone beds from eight inches to two feet in thickness, separated by such partings, that inspired Dr. Locke of the First Geological Survey to call them the Beautiful Quarry stone. Much thicker shale beds are not uncommon, however. Almost without exception each of the sandstone beds in this province is characterized by curious raised marks and tracks on its under surface, and by the bore holes and leaf-like impressions of the worm *Spirophyton* on its upper surface. The sandstones are moderately fine-grained, breaking equally well in any direction, yellowish or buff in color near the outcrop, bluish-gray under cover.

"Sandstones and shales of this type make up the lower 150 feet of the Vanceburg facies of the Cuyahoga; above this the sandstones become thinner and farther apart and higher still give way entirely to shale.

"Although beds have been quarried at several horizons in the Vanceburg facies, only one has been at all extensively worked, and this proves to be the only sandstone member that can readily be traced over any considerable area. The name Buena Vista sandstone, proposed originally by Edward Orton, is adopted for this member.

"At Buena Vista this member is known as the City ledge, and is there the lowest sandstone in the Cuyahoga. It varies from three to six feet in thickness, is underlain by five feet of shale (the basal bed of the Cuyahoga), and is separated from the main body of sandstone by 16½ feet of shales. It is, in addition to being the lowest sandstone in the Cuyahoga, the only one set off by such shale beds. From this locality the member has been traced northward to Rarden, a distance of 21 miles, where it undoubtedly is the bed that was quarried for several years. From Rarden it can be followed without difficulty southeastward down Scioto Brush Creek to its mouth, a distance of 14 miles. In this distance the member has been exploited at Otway, Henley and McDermott. The beds formerly quarried on Carey Run west of Portsmouth are believed to be at the same horizon, but it has not been followed from Buena Vista up the Ohio River to this locality. It has been seen in good development on the west side of the Scioto River north of Scioto Brush Creek; it has been followed over the entire western half of Pike County; it is known to extend into Ross County, and has been seen several miles east of the Scioto River in Pike County. The area of the member, as thus outlined, extends far outside the limits of the Vanceburg facies of the Cuyahoga, but these are the only sandstone beds of any thickness whatever that do extend beyond these rather sharply marked limits. Throughout much of its area in the Scioto shale facies, the Buena Vista member is the only sandstone in the Cuyahoga shales which attains any degree of thickness. It is perhaps of interest to note that the shale interval between the base of the Cuyahoga and the bottom of the Buena Vista member increases

[1]Geol. Surv., Ohio, Vol. II, p. 627.

to the northward and eastward. In the southern part of Ross County, northwest of Summit, the base of the member is 89 feet above the base of the Cuyahoga, while in the hills east of Piketon in Pike County, it is about 226 feet above the base.

"The Buena Vista member is not of the same quality, structure and thickness in all parts of this area. At Rockbridge, just below Buena Vista, where it was first quarried, the member is a single bed of sandstone from three feet three inches to four feet one inch in thickness (Andrews' figures). At Buena Vista there is a single bed, but on Lower Twin Creek, where were located the most important quarries in the Buena Vista region, the member is always composed of two beds. In Caden's Lower quarry, at the mouth of Vastine branch, which enters Lower Twin Creek about two miles above Buena Vista, the member consists of two beds, the lower one foot nine inches thick, the upper three feet four inches. Mr. Adam Heller, formerly a foreman in the quarries, told the writer that the greatest thickness known to him was in Dog Hollow, another branch of Lower Twin Creek, where the lower bench was two feet and the upper four feet thick. As will be shown shortly the member is thin and worthless to the westward. Lower Twin Creek flows from northwest to southeast, and the head, six miles above the mouth, lies in this worthless portion of the area where the Buena Vista member is only a few inches thick. There appears to have been very little quarrying done on this stream above the mouth of Vastine branch, although that branch, which enters from the northward, was the locus of important quarries.

"The first large stream northeast of Lower Twin Creek is Upper Twin Creek; in the upper portion of its valley, and about four miles in a direct line north, northeast of Buena Vista, the Buena Vista consists apparently of three beds, which in ascending order are six inches, one foot eight inches and two feet three inches thick. It has not been exploited on this stream. The member has been identified at other places in this locality, and six miles north on Big Run, a tributary to Rocky Fork, the Buena Vista is well developed. The lowest bed seen, not known to be the base of the member, is about 20 feet above the base of the Cuyahoga. Four beds were seen, which in ascending order are 11 inches, one foot two inches, two feet four inches, and two feet six inches thick. At this locality the shales under the Buena Vista were not seen, but from the behavior of the stone there can be no doubt about their presence. It is not easy to see the Buena Vista beds in position because this soft shale is readily washed out by the streams, allowing the blocks of the Buena Vista to slip down the hill, and slabs 15 feet square were noted besides many blocks of lesser dimensions. The size of these blocks shows that the stone would quarry well for sawing, but the locality is too inaccessible for consideration at present. The shales over the member can be seen, followed by the main mass of sandstones of the Vanceburg type.

"At Rarden, 10 or 11 miles north of Big Run, the Buena Vista member has been quarried, and it has been recognized at intervening points. There are two chief beds of sandstone, the lower from four feet nine inches to five feet six inches thick, the upper from three feet three inches to five feet thick, but they are not so reliable as at Buena Vista, since they are more broken by joints along which limonitic deposition is not infrequent.

"The localities so far briefly described all lie along the line between Scioto and Adams counties and for the most part in Scioto County. So far as has been observed, at all points west from this line, the Buena Vista member becomes thin and worthless. Near Mineral Springs, three miles southwest of Rarden, it appears to be represented by a three-inch bed of sandstone. On the head of Churn Creek, 13 miles to the southward and seven miles north, northwest of Buena Vista, just over the divide to the northwest from the head of Lower Twin Creek, the member is represented by two sandstones, the lower one 13 inches and the upper about eight inches thick. At Vanceburg, Ky., three miles southwest of Buena Vista, the only possible equivalent of the member, and that occurring precisely where it would be expected, is eight inches thick.

"When the Buena Vista member is traced southeastwardly from Rarden down

Scioto Brush Creek, it is found to thicken, and the number of sandstone beds that compose it increases but the average thickness of the individual beds is diminished. At Otway the member is 10 feet thick with eight or 10 regular beds of sandstone, the two upper ones 16 and 19 inches thick. At Henley the member is 12 feet six inches thick, and the sandstone beds in descending order are of the following thickness in inches, 12, 18, 13, 17, 12, 9, 12, 44. Thin shale beds make up the remainder of the total. The member can be seen at several localities between Henley and McDermott. The exact thickness at McDermott is not known to the writer, but it appears to be about 28 feet, of which only the upper 20 feet are worked.

"The Buena Vista member has been seen in good development at several localities on the west side of the Scioto Valley. On Pond Run, two miles south of McDermott, and from there southward to Portsmouth and the Carey Run quarries, the structure and thickness of the member and quality of the stone appear to be much the same as at McDermott. This, however, is near the eastern limit of the valuable deposits of stone, for on the east side of the Scioto Valley, two miles wide, where the member has been seen at Portsmouth and Lucasville, it is so altered as to be much less valuable or quite worthless. Indeed, at Rushtown, at the mouth of Scioto Brush Creek, on the west side of the Scioto, the member does not appear to be so desirable as farther west.

"Northward from McDermott, on Reed's Run, Big Run and Bear Creek, or as far as the north line of the county, deposits occur equal in value to those at McDermott, if suitable conditions for quarrying can be found. Although the member can be followed over the entire western half of Pike County, and into the southern part of Ross, it is with decreasing thickness and declining value. The component beds grow thinner, and the sandstones tend to become more clayey and less resistant to weathering. Sandy shales form a large fraction of the member. Deposits of more than local value probably do not extend much north of Scioto County, and over most of its area in Pike County it is worthless."

BUENA VISTA

The village of Buena Vista, situated on the bank of the Ohio River in the southwestern corner of Scioto County, is one of the oldest quarrying centers in Ohio, and for many years it was one of the most important. The surface rocks of the river valley are the Ohio shales, and are succeeded upward in turn by the Bedford sandstone and shales, the Berea sandstone and shales, the Sunbury shales and the Cuyahoga sandstone and shales. While the Bedford at this locality contains one or more layers that may be used for structural purposes, and the Berea, according to Professor Andrews, is still more fortunate in this respect, the Cuyahoga formation alone has yielded building stone of excellent quality and large quantity.

Early History.—General Nathaniel Massie is said to have gotten possession, by purchase or settlement, of land along the river at Buena Vista as early as 1801, and a little later he sold part of this to Joseph Moore, who built a residence in 1814, in the valley between Buena Vista and Rockville, of stone taken from the adjacent hills. This house, the oldest in that part of Scioto County, still stands, and the stone is in good condition. Moore in early life was a stonecutter, and from 1814 to 1830 he rafted large quantities of Buena Vista stone, taken from hillside blocks, to Cincinnati, where it was used for building

purposes. He was succeeded in the stone business in 1831 by John Loughry, who located at Rockville, and brought with him 60 or 70 men and 16 yoke of oxen to supply stone for canal locks, then in course of construction at Cincinnati. While Moore simply used blocks which nature had broken from the ledges that outcrop on the hillside, Loughry quarried the bed-rock, at or near the top of the hills, and this stone, though it has had the very severe tests that canal locks are subjected to, is now in good condition. Lower beds were worked later, and in time Loughry quarried the City Ledge only.

The stone at first was dragged by oxen to the river bank, but later chutes were constructed on the hillside down which the stone slid. Finding this unsatisfactory, good roads were built from the quarries to the river and the stone hauled in wagons. Finally inclined railways were constructed and small locomotives hauled the stone to the top of the incline where it was lowered to the bottom by cable.

At first stone was shipped in rectangular blocks but later it was sawed by hand. In 1847 a sawmill was erected on the river bank and the finished stone increased in popularity, and its market widened, especially for architectural purposes. Later, the firm of Miller & Son built a mill, so that the output of sawed stone was largely increased. The ruins of these old mills may still be seen at Buena Vista. Loading and shipping on the river in early days were likewise very crude, and the rafts were succeeded by barges, on which the stone was placed by powerful hoisting machines. In the beginning these barges were not returned, but as lumber became more expensive they were towed empty up stream, much as coal barges are at the present time.

Loughry retired from active work in 1856, and passed away in 1862. His son succeeded him in the management of the property, but in 1865 he sold it to W. L. Caden & Brother, who worked the quarries on a large scale until 1873, when they resold the property to Loughry. Of course Loughry and his predecessors were not the only operators in the field. As late as 1869, according to Professor Andrews, Caden & Brother were selling annually 150,000 cubic feet of stone; a Mr. Mueller about 200,000 cubic feet, and J. W. Adams also was a large producer from his own quarry, and that of J. W. Flagg on Lower Twin Creek.[1] Between Buena Vista and Portsmouth were other quarries in the Cuyahoga formation, especially at Carey's Run and Stony Run. The output of the latter quarries was in large part hauled in wagons to Portsmouth, where it kept two sawmills busy.

Geology.—The topography of the western half of Scioto County, outside of the river valleys is very rough. The hills at Buena Vista rise several hundred feet above the flood plain, and on their steep slopes

[1]Geol. Surv. of Ohio, Rep. of Prog. in 1869, p. 72.

may be seen outcropping all the formations referred to below. Rocks thus exposed naturally attracted attention of the pioneers, and quarrying began at an early day.

Section of Rocks Near Buena Vista, by Professor E. B. Andrews,[1] *with Names of Formations Supplied by J. A. Bownocker*

	Ft.	In.
Mantle rock (soil and subsoil).		
Cuyahoga formation		
Yellow sandstone	3	0
	1	3
Shales and sandstone, thickness not given		
Yellow sandstone	3	4
	0	8
Shales	8	0
Yellow sandstone	3	2
Shales and sandstone	47	10
Beautiful Quarry of Dr. Locke	20	4
Shales and sandstone	34	5
City Ledge, 3 ft. 4 in. to	4	1
Blue clay	5	4
Sunbury shales and clay	16	4
Berea sandstone and interbedded clays	24	0
Bedford formation.		
Shales and sandstone	24	2
Sandstone, irregular thick ledge	5	3
Shales and sandstone	25	5
Sandstone, Trust Company ledge	1	6
Shales and sandstone	5	9
Unseen	51	0
Ohio shales to Ohio River level	255	0

As previously stated Joseph Moore, who first quarried stone at Buena Vista, did not work the rocks in place, but the large blocks lying on the slopes or at the foot of the hills. John Loughry, however, could not rely on this source for the ten canal locks at Cincinnati, and so began working three ledges at or near the top of the river hill. This was a fortunate choice, for the stone in these locks is now in the main in good condition after 80 years of the severest tests.

City Ledge

A few years later Loughry began working a layer near the base of the Cuyahoga formation, about 220 feet above the flood plain of the

[1] From a pamphlet entitled "Description of the Loughry Lands," published at Portsmouth, Ohio, in 1891. Professor Andrews' contribution to this is dated July 20, 1872. A number of the historical statements concerning the stone industry at Buena Vista are taken from this pamphlet.

river, and this stone became so popular with architects and builders at Cincinnati that it was known as the City ledge, and after 1843 quarrying was practically limited to this layer. The City ledge usually varies from three to four feet in thickness, has a uniform bluish-drab color, a medium grain, carves well, appears to good advantage and is strong and durable. Two impurities are found in places which mar the stone. Iron pyrite occurs in small quantity, and on weathering may produce light spots on the surface. More objectionable are the petroleum compounds which in some places exude on the surface, and render the stone unsuitable for anything except the rougher forms of work. "For beauty, durability, firmness under pressure, ease of working and general good behavior under the chisel," says Professor Andrews, "I know of no stone in the country equal to it." A test of the stone made at the Smithsonian Institution many years ago showed a crushing strength of 10,320 pounds per square inch.[1] Blocks containing as much as 300 cubic feet have been quarried and shipped, but the average was about 45 cubic feet. These blocks, of course, were in most cases hauled to the mill and sawed into pieces to meet the market demands. This ledge was worked as far as 100 feet in the hills on the river front, and the terrace thus formed is conspicuous. About two miles north of the village the City ledge is represented by two workable beds, the upper one measuring three feet and the lower one two and one-half feet.

Nothing better can be done at this place than to quote two paragraphs from the description of this ledge by Dr. Edward Orton:[2]

"The southwestern portion of Scioto County and the southeastern corner of Adams County, two adjoining districts, were once the most important localities in Ohio for the production of building stone. In the earlier days of the State an engineer of reputation, employed upon the construction of canals, became conversant with the then known building stones of the state, and recognizing the great value and accessibility of the ledge, commonly known as the Buena Vista Freestone ledge, bought a large territory here, and began the development of the quarries in a large way. Other horizons of good rock were found at various levels, but this one bed, by its color and quality, supplied the Cincinnati market almost exclusively. Its reputation spread throughout the whole Ohio Valley and beyond. Large quarries were opened on both sides of the river, government patronage was secured, and material for the construction of custom houses and other public buildings was ordered from the Buena Vista quarries. So great was the demand for this stone that material of poor quality, as well as good, was hurried into the market. The green stone, while full of quarry water, was laid in massive walls, and the bad behavior of this material soon excluded the stone almost entirely from the market. It is, however, as good now as when it earned its high reputation, but needs careful and conscientious selection and suitable seasoning.

"Just below the horizon of the Buena Vista stone lies the Berea shale, a bed of highly bituminous and very fossiliferous black shale, ranging from 15 to 30 feet in thickness. Its bituminous composition makes it a source of petroleum, which rises

[1]Geol. Surv. of Ohio, Rep. of Prog. for 1869, p. 71.

[2]Geol. Surv. of Ohio, Vol. V, p. 601.

into the sandstone courses that lie above it. This is the source of one of the worst impurities of the Buena Vista stone. When followed under cover it is found loaded with petroleum or with tar, which seems not only to disfigure the stone but to weaken it to some extent; and other impurities in the stone are masked for the time by this bituminous matter. The oil-bearing stone is tolerated only in rough, heavy work. Some of the stone contains sulphide of iron, which, on exposure to the weather, becomes oxidized to the sulphate and goes into combination with compounds of aluminum, and appears on the surface of the stone as a white efflorescense, which has the characteristic taste of alum. Trains and nuggets of pyrite appear in the shales associated with this sandstone, but are not very perfectly visible to the naked eye in the City ledge (the name now applied to the stratum proper of Buena Vista stone). The rock is quarried by channeling and wedging in the same manner as in the quarries of the Berea grit in northern Ohio. No stone is extracted for the market during the winter months, but this time is occupied in removing the cap-rock and in channeling. The behavior of the material when properly selected is apparent in a number of important structures in Cincinnati, and that of the unselected material may be seen in the custom house and other buildings in Chicago. The material has also been used with good and bad results in a number of other cities and towns, including Louisville, Kentucky, Pittsburgh, Pennsylvania, and Detroit, Michigan."

In addition to a large use for architectural purposes, this ledge has long been popular with engineers. The piers of the Suspension and Louisville & Nashville Railroad bridges at Cincinnati are constructed of it, and the same is true of the Norfolk & Western bridge at Kenova. Still larger has been the demand for the stone for ordinary bridge and culvert work and for flagging and curbing.

Beautiful Quarry

About 35 feet above the City ledge is the Beautiful Quarry stone of Dr. Locke, of the first geological survey. This has a thickness at Buena Vista of approximately 20 feet, and consists of beds of sandstones varying from six inches to two feet in thickness, with a few beds of shales. This stone was never quarried except in a very small way, for the demand was for the City ledge. It contains a large supply suitable for building and structural purposes.

As has already been stated the three highest ledges shown in the section at Buena Vista were used in the canal locks at Cincinnati, and have abundantly demonstrated their lasting quality. They may be considered first-class for bridge piers and general structural purposes. Other layers than these and the City ledge have not had a fair trial, but Professor Andrews who visited the locality when the quarrying was at its height wrote, "Could the stone from other layers be once fairly introduced, I have no doubt of its value and popularity."

Decline of the Industry

Several things contributed to the decline of the industry and its

abandonment. As stated by Dr. Orton on a preceding page the demand for the City ledge became so large and insistent that inferior material was marketed. This soon reacted, and the call for the stone became smaller. The growing use of cement operated notably in the same direction, especially for bridge and culvert work. As quarrying progressed, and the ledge was worked further and further into the hillside, the amount of stripping increased, and the expense of getting out the stone blocks grew proportionately. Further, tracks were laid up the narrow valley and stone quarried beyond the river front hills, making the expense of transportation a considerable factor. Finally it was found that quarries dependent on the uncertainties of river shipment could not compete in many markets with quarries located on railroads, so that between 1880 and 1890 a notable decline set in, which continued until work finally ceased. The last of the organizations, the Buena Vista Freestone Company, went into the hands of a receiver in 1904, and closed in 1909.

A quarry of some importance was that of J. M. Inskeep, in the Ohio Valley, about 12 miles below Portsmouth. According to Dr. Orton the stone measured 30 feet and consisted of about 20 different layers, the lowest of which was approximately 32 inches in thickness. "The courses," he says, "are remarkably even in thickness, but those above the lowest do not yield a strictly first-class material."[1] For some years this quarry had a large market at Columbus, but the decrease in the demand for stone affected it as it did other quarries and the works were abandoned.

Carey's Run

Since the sandstone so well developed and exposed at Buena Vista dips to the east or southeast, it lies nearer the river level, and hence is more accessible towards Portsmouth. While the stone has been worked at several points in the Ohio Valley between these two places, the most important quarries were on Carey's Run, about two miles below Portsmouth. Following is a section in the old Reitz quarry about three miles above the mouth of Carey's Run:

Cuyahoga formation.	Ft.	In.
Sandstone and shale stripping	10 to 30	--
Sandstone	1	4
Shales	--	1½
Sandstone	2	4
Shales	--	3
Sandstone	1	3
Shales	--	0½
Sandstone	1	2
Shales	--	3

[1]Ibid., p. 601.

	Ft.	In.
Sandstone	--	10
Shales	--	2
Sandstone	1	4
Shales	--	4
Sandstone	--	4
Shales	--	2
Sandstone	--	3
Shales	--	3
Sandstone	--	7
Shales	--	1
Sandstone	--	9
Shales	--	2
Sandstone	--	11
Shales	--	1
Sandstone	--	11
Shales	--	1
Sandstone	--	11
Shales	--	1
Sandstone	--	4
Shales	--	1
Sandstone. Breaks uneven and weathers to red-brown. Probably rejected	1	6
Shales	--	8
Sandstone	1	--
Shales	--	3
Sandstone	1	8
Shales	1	2
Sandstone	--	8
Shales	--	2
Sandstone	--	11
Shales	--	2½
Sandstone. Breaks uneven and weathers to red-brown. Probably rejected	--	8
Shales	--	9
Sandstone. Weathers to dull brown color	1	2
Shales	--	6
Sandstone	1	--

This quarry was opened by Reitz & Co. in 1867, who hauled the stone in wagons to Portsmouth where it was sawed. The stone is of good quality, and was used in the Court House at Athens and the Western Penitentiary of Pennsylvania.[1] Stripping and lack of shipping facilities are the great obstacles to quarrying. The works were abandoned in 1909.

One of the earliest steam sawmills for stone in the west was at Raven Rock, in this vicinity. It is reported to have been erected about 1847, and used until the great flood of 1884 washed it away. The first large order received by this pioneer company is said to have been for the old Cincinnati waterworks. "For flagging," says Dr. Orton,

[1]Geol. Surv. of Ohio, Vol. V, p. 600.

"the stone is unequaled in the Ohio Valley, as it wears evenly, always gives foothold, and is in every way satisfactory." The stratigraphic position of the rock is the same as the City ledge. While there is no longer any quarrying at this place the supply of available stone is large.

McDERMOTT

The station McDermott, on the Cincinnati division of the Norfolk & Western Railway, in the western part of Scioto County, is now the most important site for quarrying sandstone in Southern Ohio, and in fact its only rivals in the State are Berea and South Amherst.

About 1883 stone from the hills between Rardin and the Scioto River was quarried for use on the railroad, and in this manner its excellent quality was discovered. A small quarry was opened at Otway, nine miles west of McDermott, by W. R. Smith & Sons, and late in 1886 the shipping of stone was begun. Encouraged by the results a mill was erected, but it was found that only a small per cent of the stone was suitable for sawing and the quarry was abandoned in 1898. About the same time the quarry was opened at Otway, another one was started at Freestone, one and one-half miles west of McDermott, but no mill was erected, and the quarry was abandoned about 1907.

In July 1894, W. R. Smith & Sons opened a quarry at McDermott, and the present industry dates from that time. Four years later the McDermott Stone Company took over this quarry, and still owns and operates it. The next important step in the stone industry was taken in 1905, when the Waller Brothers opened a quarry just below McDermott, and it has proven a worthy competitor of the pioneer plant at this place.

The quarry of the McDermott Company lies about one mile northwest of the village, and its base is approximately 78 feet above the railroad station. The sawmill, erected in 1899, is at the village, and the stone is hauled from the quarry on a railroad owned by the company. The quarry is located on a low, dome-shaped hill and there is usually from four to 20 feet of stripping.

Section in Quarry of McDermott Stone Company, McDermott, Scioto County

	Ft.	In.
Cuyahoga formation.		
Mantle rock, shales and sandstones	4–24	--
Buff sandstone. Used in general building trade	1	4
Shales	--	1
Buff sandstone. Used in general building trade	1	5
Shales	--	2½
Buff sandstone. Used for flagging and burial vaults	1	1
Shales	--	0½
Buff sandstone. When color is uniform, used for general purposes, otherwise for bridge work	1	3
Shales	--	2
Buff sandstone. Suitable for foundations, street crossings, etc	--	8
Shales	--	1
Buff sandstone. Excellent quality	1	7
Shales	--	4½
Blue-gray sandstone. Suitable for buildings, foundations and street crossings	--	9
Shales	--	0½
Blue-gray sandstone. Good quality	--	9
Shales	--	2
Blue-gray sandstone. Good quality	1	3
Shales	--	1½
Blue-gray sandstone. Good quality	1	--
Shales	--	1
Blue-gray sandstone. Develops iron spots on exposure. Used for grave vaults	1	--
Shales	--	1
Blue-gray sandstone with concretions, rejected	1	3
Shales	--	7
Blue-gray sandstone. Thickest and best in quarry for building purposes	2	8

The following layers are reported below the base of the quarry by J. S. Smith, but they may not reach the bottom of the sandstone:

	Ft.	In.
Sandstone	--	8
Shales	--	2
Sandstone	1	--
Shales	--	8
Sandstone, broken	1	4
Shales	--	3
Sandstone	1	8
Shales	3	4
Sandstone	3	6

These beds are reported of good quality, but below the ground water level, and hence to work them would require pumping.

The McDermott Company owns about 600 acres of land in the vicinity of McDermott, 340 of which are underlain with workable stone. In 1913 the pay roll of the company numbered 120 on the average.

Section in the Quarry of the Waller Brothers Stone Company, McDermott, Scioto County

	Ft.	In.
Cuyahoga formation.		
Sandstone and shales, rejected	15	--
Blue-gray sandstone of good quality	1	3
Shales	--	1
Blue-gray sandstone. Good in places	2	--
Shales	--	2
Blue-gray sandstone with spots of clay on top. Only nine inches of good stone	1	--
Blue-gray sandstone. Excellent quality	1	4
Shales	--	1½
Blue-gray sandstone of poor quality	--	8
Shales	--	0½
Blue-gray sandstone of excellent quality. Yields 16 inches of sawed stone	1	7
Shales	--	4
Blue-gray sandstone with brown streak near base. Used for burial vaults	1	4
Shales	--	1
Blue-gray sandstone of excellent quality	--	10
Blue-gray sandstone	--	4½
Blue-gray sandstone	--	4½
Shales	--	½
Blue-gray sandstone of poor quality. Used for foundations	--	8
Shales	--	1
Blue-gray sandstone. Often rejected	--	6
Concretionary ledge. Used for breakwaters	1	6
Shales	--	6
Blue-gray sandstone of poor quality	--	6
Shales	--	2
Blue-gray sandstone. Thickest in quarry	2	6
Shales	--	0½
Blue-gray sandstone. Used for foundations only	--	8
Shales	--	3
Blue-gray sandstone. Always rejected	--	6
Shales	--	5
Blue-gray sandstone of fair quality	1	7

This section shows 14 courses of good stone, and the workmen refer to them by numbers beginning at the top.

The stone in the two quarries at McDermott is from the same group of beds, and is so similar that separate descriptions are unnecessary.

Strength

Tests of the McDermott stone, made by Professor Judd of the Ohio State University, give it an excellent rating, both from the standpoint of crushing and transverse strength. For the first, two-inch cubes were used, and for the transverse strength pieces about four inches in length and two inches in each of the other two dimensions, and all were air dried. The cubes were laid in a thin bed of plaster of paris to offset any possible irregularities in the surfaces, and the blocks for transverse strength were on supports three inches apart, and the pressure was applied at the middle, as explained on page 76.

Crushing Strength of McDermott Sandstone

Variety.	Position. Bed or edge.	Crushing strength. Pounds.
Blue	Bed	33,350
Blue	Bed	41,760
Blue	Edge	24,150
Blue	Edge	28,600
Gray	Bed	41,750
Gray	Bed	34,900
Gray	Edge	33,750
Gray	Edge	27,130
Buff	Bed	27,850
Buff	Bed	38,160
Buff	Edge	30,450
Buff	Edge	39,730

Transverse Strength of McDermott Stone

Variety.	Position. Bed or edge.	Transverse strength. (Modulus of rupture)
Blue	Bed	1,375
Blue	Edge	1,415
Gray	Bed	1,516
Gray	Edge	1,430
Buff	Bed	1,668
Buff	Edge	1,640

Other Physical Properties

The stone is medium fine in grain, even-bedded, easy to work and carves well. Occasional holes are found in the rock, and it seems probable that they were formed by worms when the stone was simply a mass of sand. While these holes injure the appearance they do not mar the rock in other respects. More objectionable are lumps of clay which are occasionally found in certain layers. These vary greatly

in shape and are most common in the upper part of the beds. They were probably formed by mud from the overlying shales, working down into the sand before it had been cemented to solid rock. In some places these lumps of clay, though they constitute a small proportion of the mass, are so numerous that they make the stone worthless, except for the roughest forms of work. When used in walls, light colored spots sometimes develop, and the surface crumbles as if the cement had been removed. This may be prevented by covering all except exposed surfaces with a coat of damp-proof paint, of which there are several good brands on the market.

Quarrying the stone presents no unusual features. The overburden is removed with steam shovels or hand labor. The channeling machine is then called into use, and this and steel wedges reduce the stone to desired sizes. The shale partings provide horizontal breaks. About 70 per cent of the stone can be sawed and used in high-grade building trade. The remaining 30 per cent is used for foundations, retaining walls, culverts, etc.

The color, where unexposed to the air, is blue-gray, but where the exposure has been long the tint is gray, and where the air and water have had access for ages the color is light yellow. That the last two shades are a result of weathering is proven by occasional blocks which have a blue-gray core, surrounded by a strip of gray and a yellow surface. Further, layers having a blue-gray color, where under cover, may sometimes be traced to hillsides, where they are exposed to the atmosphere, and have a yellow tint. Color is largely a matter of taste, and there is a call for the three shades. The yellow is permanent, except when changed by dirt, and makes a handsome wall or trimming where warmth is desired. The blue-gray stone changes slowly to gray, and later to buff or yellow.

Chemical Composition

Below are two analyses from layers 2, 3, 4, 5 and 6 of the Waller Brothers quarry. The first is the blue-gray stone and the second the yellow. Professor D. J. Demorest, analyst.

Analyses of McDermott Sandstone

	Blue-gray stone.	Yellow stone.
Silica, SiO_2	85.60	84.50
Alumina, Al_2O_3	7.25	6.35
Iron oxide, Fe_2O_3	2.60	3.00
Titanium oxide, TiO_2	.75	.75
Calcium oxide, CaO	trace	trace
Magnesium oxide	trace	trace
Loss on ignition	1.70	2.15

Use and Market

The McDermott stone has an extensive market for building purposes, bridges, and for lining grave vaults. As a building stone, it is accorded high rank. The grain is uniform, the color agreeable, the beds even and the general effect pleasing. Reference has already been made to its strength which is adequate, and its durability has been amply proven. The market is large, and extends from Maine to Missouri and from New Orleans to Alberta, but the principal call is from Columbus and Cincinnati. Among the structures in which the McDermott stone is used, in whole or in part, may be mentioned the new capitol at Alberta, British Columbia; Woolworth Building, Salem, North Carolina; Johns Hopkins Hospital, Baltimore; Brown Residence, New Orleans, and the Pickard Flats, Chicago. Several fine residences in Cincinnati have walls of this stone, and it has enjoyed a large market in New York for trimming buildings of this class.

The demand for grave vaults is increasing. The stone is sawed into thin slabs and the grave lined with them. In other words, the stone takes the place of a rough box, and of course has a great advantage in durability.

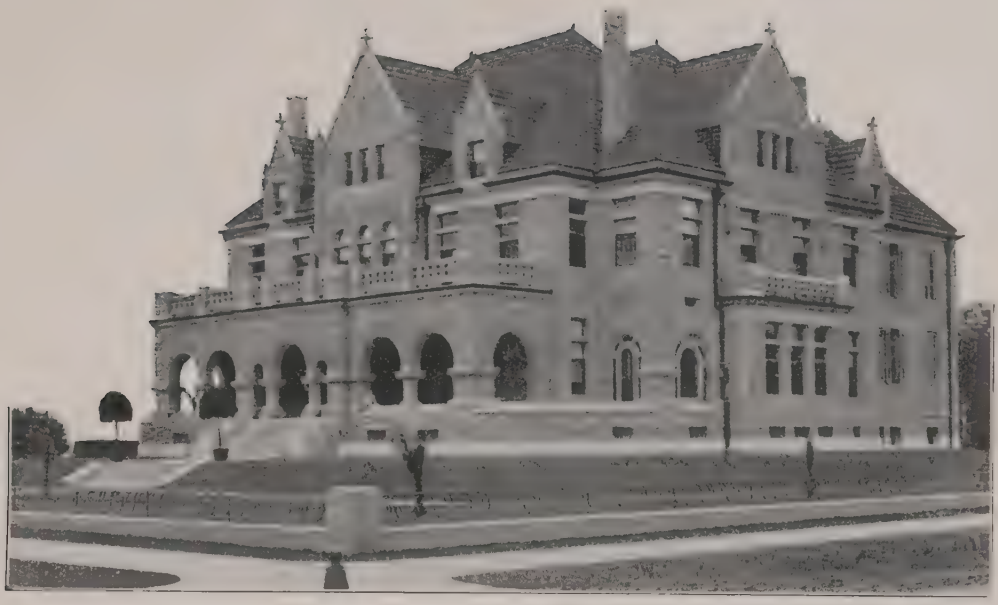
Rarden.—The village Rarden, on the Norfolk & Western Railway, in the western part of Scioto County, was for years a quarrying center of some importance. About 1892, the Stewart Brothers, of Buena Vista, opened a quarry at Rarden, and finding the stone of good quality erected a mill in 1896. The quarry, however, did not keep the mill busy, and stone for sawing was purchased at Freestone, and later at McDermott. About 1904 the quarry at Rarden was abandoned and a new one opened by the Taylor Stone Company, at the same horizon on the next hill west, 410 feet above the railroad tracks, where the following section was measured:

Section in Old Quarry on L. Taylor Farm at Rarden.

Cuyahoga Formation.

	Ft.	In.
Mantle rock and sandstone.		
Sandstone. Massive ledge with irregular brown lines. Some parts free from them	5	--
Shales	--	3
Sandstone of poor quality. Never used	1	--
Shales	--	3
Sandstone. Quality usually poor. Perhaps 100 carloads shipped	5	3

The quality of the stone in the second quarry was not usually suitable for anything but bridge work, owing to the colored streaks previously referred to, and the increasing use of cement for this purpose



A.—Residence at New Orleans, Louisiana, built of sandstone from McDermott, Ohio.

B.—Quarry in Cuyahoga sandstone, McDermott, Scioto County, Ohio. Photograph by J. E. Hyde.

greatly reduced the market, so that about 1907 quarrying ceased. Since that time the mill has been kept busy sawing stone transported from McDermott.

Henley.—This station, on the Norfolk & Western Railway, midway between McDermott and Rarden, is unique in having had quarries opened at four stratigraphical horizons. Professor J. E. Hyde who has examined the territory has prepared the following for this bulletin:

"Quarries were formerly operated at Henley, in the Buena Vista sandstone, by both the Wellman and Reitz Stone companies. The rock measures about 12 feet, and in the Wellman quarry consists of eight courses, which vary in thickness from nine to 44 inches. The rock is similar in the Reitz quarry, though measurements were not made. The lowest course is 44 inches in thickness and was most prized. It is a very pleasing light buff in color, just bordering on gray, as exposed near the outcrop. The others are buff. The sandstone is moderately coarse and is said to saw well. Work ceased about 1907.

"One hundred and eighteen feet above the base of the Cuyahoga, or 72 feet above the top of the Buena Vista member, a massive ledge of moderately coarse, buff sandstone has been opened on the Reitz property. It is five feet five inches thick, and is overlain with similar sandstones from one to three and one-half feet thick, with thinner beds of shale. Much was hoped of the bed when it was discovered, but before it had been followed far enough into the hill to be free of the numerous cracks which are fatal to a stone destined for the saws, work was abandoned.

"The Berea sandstone, which has been opened at this place by the Wellman Stone Company, lies in twelve fairly even beds, and with the interbedded shales measures 37 feet, but this may not include the whole of the formation. The stone is moderately fine-grained, and varies from blue to very light blue-gray in color when freshly exposed. Small grains of pyrite are common and, oxidizing quickly, stain the surface a rusty brown. The stone splits readily and has been shipped for curbing, bridge work and retaining walls. Work ceased in 1907.

"Two quarries in the Bedford formation have been opened at Henley. In the Wellman quarry there is a vertical exposure of 26 feet, of which only $13\frac{1}{2}$ are sandstone. The exposure in the Reitz quarry is a little greater vertically, but otherwise it is similar. The lowermost bed in both quarries is the most valuable, and is known as the Bode ledge from the man who first quarried it years ago. This is a single bed of fine-grained, bluish-gray sandstone, which is reported to retain its color well, and has been used for building purposes. It varies in thickness from two feet six inches to four feet eight inches. The remainder of the sandstone in the Bedford quarries at Henley has a light gray color."

The McDermott stone was quarried also by J. N. Inskeep along Duck Run, about one and one-half miles north of McDermott, but the quantity of stone removed was not large.

Waverly.—The hills along the Scioto River opposite Waverly contain some brown stone in the Cuyahoga that has been worked on a small scale for building purposes. The quarries were located on the Gregg and Odell farms, and the stone had a light brown but somewhat uneven color. Apparently the quantity of stone with this shade is limited, and no quarrying has been done for many years. It forms the

front of the Hayden-Clinton National Bank at Columbus. Since the above was written the east side of the river front hills have been examined from Waverly to a few miles north of Omega, and the brown sandstone found wherever it is due. The rock measures six feet in thickness opposite Omega, and many large blocks lie on the hillside where they can be gotten with the minimum expense.

Lithopolis. — The village Lithopolis, on the western edge of Fairfield County, was for many years the site of a quarry in sandstone of Cuyahoga age. The following section of the rocks at that place was measured by Dr. C. R. Stauffer:[1]

	Ft.	In.
Cuyahoga formation.		
Several fairly even compact layers of grayish sandstone, followed in ascending order by bands of arenaceous gray shale and soft uneven sandstone layers to the crest of the hill at the Leyendecker quarry. The shales contain fragments of plants, but no other fossils were found in these layers	31	--
Compact even-grained blue freestone. This is the only layer of sandstone extensively worked in the quarry where it is said to extend for hundreds of feet without a cross joint	4	--
Layers of sandstone interbedded with shales and thin shaly sandstone outcropping above the covered bridge and along the steep bank below	31	--
Massive layer of blue, but frequently iron-stained sandstone	2	--
Arenaceous gray shales and thin layers of blue sandstone	4	2
A massive layer of iron-stained blue sandstone	2	9
Very soft gray shale composing the base of the formation, wherever this part has been found outcropping	5	--

Only two ledges of sandstone in this section have been worked, the one four feet in thickness and another one of half that measurement, which lies beneath the shales and sandstones which measure 31 feet. The stone, where unweathered, has a blue-gray color, a moderate size grain, is strong and works well. Many years ago it was sawed at the quarry, but in later years the mill was dismantled and the stone was hauled in wagons to Canal Winchester, where it was shipped to Columbus and sawed to desired sizes. The principal use of the sawed stone was for sills, caps and steps. Within the past three or four years the quarry has been abandoned, owing to market conditions, lack of shipping facilities and the heavy stripping.

A pocket of brown sandstone was formerly worked on the old Claypoole Farm less than two miles west of south from Carroll, Fairfield County. The ledge quarried was usually less than 10 feet thick

[1]Geol. Surv. of Ohio, Fourth Ser., Bull. 14, p. 116. See also Prosser, C. S., Am. Geol., Vol. XXXIV, p. 337.

and the color was not uniform. Brown stone from this quarry was used to trim Orton Hall in which offices of the Geological Survey are located. The quarry was abandoned many years ago.

Reynoldsburg.—Reynoldsburg, near the eastern border of Franklin County, is another locality where Cuyahoga sandstones were long quarried. Tradition has it that rock from this place was used in culverts and bridges on the National Road nearly a century ago. The rock of suitable quality forms layers varying in thickness from three to 48 inches, and are separated by beds of shale that usually range from one to five inches. The total thickness of workable stone and included shale measured about 18 feet, but this may vary from place to place. The stone was sawed and shipped to Columbus, where it was used for sills and caps. The quarry and mill were closed two or three years ago.

Along Blacklick Creek, about three miles north of Reynoldsburg, this sandstone was formerly quarried for building and other structural purposes. The stone usually lies in even beds of suitable thickness, but in places the cementing is poor and the stone friable. Moreover, it contains a large percentage of clay which increases its absorption of water, and this on freezing may fracture the stone. The best of this rock is of fair grade only. It forms the body of the walls in the Institution for the Blind at Columbus.

The Cuyahoga sandstones in the vicinity of Columbus were formerly classified with the Berea, but their true position was shown a few years ago by Professor Prosser.[1]

Newark.—The hills in the vicinity of Newark contain much sandstone of Cuyahoga age that is suitable for all ordinary structural purposes. Rock Hill, about one mile south of the city, was formerly a quarrying center of local importance, and Marble and Ponster operated there in a small way for perhaps 25 years. A ledge of from 18 to 20 feet of moderately fine, blue-gray stone was worked, but the stripping was heavy, and quarrying was discontinued about 12 years ago. The walls above the basement of the First National Bank at Newark are from this quarry, and are in practically perfect condition after nearly 50 years. The Episcopal Church at Broad and Third Streets in Columbus was built from stone taken at this horizon from a quarry one and one-half miles south of Newark, but the recent additions to the church were from McDermott.

Across the pike from the quarry just referred to is Vogelmeier's brickyard where the following section was obtained:

	Ft.
Shales and rotten sandstone used for brick	20 to 40
Sandstone of good quality	5
Sandstone, shaly	2
Sandstone of good quality. Occasional horizontal breaks present	12

[1] American Geologist, Vol. XXXIV, p. 335.

This, of course, is the equivalent of the rock formerly quarried by Marble & Ponster. The grain is rather fine, the texture uniform and the composition apparently without objectionable constituents. Occasionally the stone shows slight banding but as a rule the color is uniform and a light buff. That unweathered is blue-gray. Vertical cracks are common but blocks of any desired size can be gotten. This stone appears to be of good quality in every respect but no quarrying is now in progress.

Warren.—Two or three miles from Warren in Howland Township, Trumbull County, is one of the best, if not the best deposit of stone for flagging in Ohio. In the higher land along the eastern border of the county the coal measures are found so that the flagging lies near the top of the Cuyahoga formation.

The best known quarries were the Austin and Kinsman, located about two and one-half miles northeast of Warren, where work began at an early day, and where the stone was secured that made the locality noted. Work was discontinued years ago and all that now remains is two holes in the ground whose sizes indicate that quarrying was not conducted on a large scale. Following is a section of the rock in the old Kinsman quarry, measured by Professor C. S. Prosser.[1]

Section in Kinsman Quarry

	Ft.	In.
Upper sandstone stratum, which is bluish-gray in color, and splits in part into fairly thin, flaggy layers; but they are not very even	2	3
Blue, somewhat arenaceous shale, which on the surface weathers to a rusty color, varying in thickness from one foot to two feet four inches	2	4
Lower sandstone, which is similar in color and bedding to the upper one; but in places it becomes one layer, one foot eight inches in thickness. The sandstone is bluish-gray, compact, fine-grained and hard. One slab had ripple marks. This sandstone has no resemblance to the Berea, and evidently belongs in the Sharpsville sandstone of the Cuyahoga terrane. The bottom of this zone and sandstone is not known	1	8

About three miles east of Warren was the Lampson quarry, also long abandoned.

Section in the Lampson Quarry

	Ft.	In.
Glacial drift	3	6
Cuyahoga formation.		
Shales, sandy and rotten	5	--
Sandstone, three or more layers aggregating	--	9
Shales	3	2
Sandstone, five or more layers aggregating	2	3
Shales	--	6
Sandstone, five or more layers	2	--

[1] Geol. Surv. of Ohio, Bull. 15, p. 328.

While the stone in this quarry is even-bedded it hardly comes up to expectations and the exposures suggest that considerable dressing would be required to make the stone a good flagging. The texture is medium in grain and the color where unweathered is bluish-gray. While this old quarry offers large possibilities the clay and especially the shale partings would add greatly to the expense.

A short distance northwest of the Lampson is the quarry of George Ewalt, who states that work was begun at that place by his father in 1850. Between 1880 and 1890 little or no work was done, but since the latter year quarrying has been carried on in an irregular way.

Section in the Ewalt Quarry

	Ft.	In.
Glacial drift	3	6
Cuyahoga formation.		
Shales, sandy	5	--
Sandstone, hard, used for building stone	--	4
Shale, blue, called soapstone	1	--
Sandstone, blue-gray, two to four layers. Used for building stone	--	8
Shale, blue, called soapstone	--	2
Sandstone, "gray." Splits into many layers but usually from seven to 11. Used for flagging, curbing and building	3	--
Shales, called soapstone	--	3½
Sandstone, "blue." Splits into 13 layers, more or less. Used for curbing, building, cross walks, etc	5	--
"Soapstone." Five feet seen	5	--

The stone has been quarried at other places in this vicinity, and especially between the Ewalt and Austin quarries. The following description of the stone in the Austin and Kinsman quarries by Dr. Orton is well worth reproducing at this place:

"The stone is adapted to the special use of flagging on account of the extreme regularity of its beds, its composition, its strength, and its durability. In evenness of bedding it is remarkable among the quarries of the county. Blocks 10 feet square and one and one-half inches thick are extracted, which, a straight-edge laid upon the surface would touch at every point. Slabs but one inch or two inches in thickness have such strength that they go without question into general use. Their fine-grained composition causes them to wear in a uniform manner, and they always give a good foothold. The only defect in the quarry is that the north and south joints do not run evenly; but as these joints are so far distant from one another as to preclude the possibility of transportation of the included masses, this defect is of but little moment. In one case a single strip 150 feet long, five feet wide, and three inches thick was raised in the quarry. The layers, although so very closely packed together, are perfectly distinct, adhering to each other scarcely more than sawed planks in a pile.

"All the townships in this neighborhood avail themselves of this extraodinary supply of flagging, and the town of Warren is said to be the best paved town in the State; Mahoning Avenue may be mentioned as exhibiting on its western side some of

the finest flagging that has ever been laid. It has been sent to distant cities in northern Ohio, western New York and western Pennsylvania, and examples of it may be seen in Pittsburgh, Mansfield, Hornellsville, Akron, etc. It has been used for general building purposes to a limited extent.

"The quarries are drained by ditches with a constant good fall. In the flagging deposit proper there are found from four to seven courses varying from one to six inches in thickness, the six-inch course being the best and highest priced. The same general character of the stone holds in the adjacent territory, but is subject to some variation of quality. It is of a light gray color, and is the geological equivalent of the stone which is extracted from the Portsmouth and Buena Vista quarries at the southern extremity of the formation on the Ohio River."[1]

The sidewalks of Warren still bear abundant testimony to the size of slabs worked and their durability. On one of the streets facing the public square a piece was found which measured over 15 feet in length and seven in width; another one 18 feet five inches in length and eight feet four in width; and a third one more than 10 feet in length by eight in width. They have been in use many years and are but slightly worn. Elsewhere in this city the stone gives plenty of proof of its durability.

None of the quarries have railroad connections and this of course limited their market and increased the expense of transportation. Besides, cement began to play a large part in the construction of sidewalks and the demand for stone for this purpose contracted, and quarry after quarry closed until the Ewalt alone makes any pretense of operating. The quantity of stone that remains, however, is large, and if the call ever comes the locality may be a greater producer than ever before.

THE BLACK HAND CONGLOMERATE

Whether the Black Hand Conglomerate is to be considered a formation or as simply a part of the Cuyahoga as claimed by Professor J. E. Hyde need not concern us in this discussion. It has, however, yielded a large quantity of stone for structural purposes, and hence requires at least a brief description.

The Black Hand is at its best from the Licking Valley, in Licking County, south to Logan, Hocking County, and its thickness, according to Hyde, is 100 feet, more or less. In texture it is conglomeritic, but the pebbles are usually less than one-half inch in diameter and their composition is generally silica or quartz. The rock is decidedly porous but is strong enough to meet the largest demands of the architect or engineer. The color is usually buff but may be gray, light brown or rarely dark brown. The stone is massive and hence bedding planes are wanting, though horizontal breaks occasionally are present. Vertical

[1] Geol. Surv. of Ohio, Vol. V, p. 580.

cracks are numerous but not enough so to prevent quarrymen from securing blocks as large as can be handled by the most powerful derricks. Cross bedding is common.

The Licking Valley from the vicinity of Hanover to Black Hand was for half a century a busy quarrying center. Canal locks were built of this stone and later the railroads used it extensively. A third call was for bridges on public roads and foundations for buildings. Concrete, however, was too strong a competitor and the quarries were all abandoned. The quantity of stone in this vicinity is inexhaustible, though not all of it is of good quality for some is too friable.

The Hocking Valley from Lancaster to Sugar Grove was another important location for quarrying the Black Hand, and it and the underlying sandstone have long been known as the Hocking Valley stone. The rock outcrops at or near the hilltops and is therefore easily available. On theRufus Conrad Farm, about two miles north of Sugar Grove, the stone has recently been quarried. Mantle rock and shales comprise from one to eight feet and are underlain with from six inches to one foot of shaly sandstone. Beneath this the rock is massive and coarse-grained, but without pebbles and may lie below the Black Hand. Bedding planes are wanting and vertical breaks while common are not numerous. The color is light brown with patches of gray and red-brown. This stone appears to be of excellent quality and suitable for buildings, especially where heavy courses are desired. For foundations and bridge work it is excellent. In the Eckert quarry, four miles below Lancaster, the section is as follows:

	Ft.
Mantle rock and shales	1 to 14
Sandstone, massive ledge	10
Sandstone, massive ledge	14
Sandstone, poor quality. Unmeasured.	

The stone in this quarry is similar in quality to that on the Conrad Farm. It is used in the railroad viaducts at Columbus and for bridge work. Probably regular work will cease with the present year (1914).

In the Bowmaster quarry at Lancaster from 25 to 30 feet of sandstone are occasionally worked. The rock may be classed as massive though occasional bedding planes occur. The stone is coarse and soft and the lower part banded with buff and gray. It lies below the Black Hand.

Sugar Grove was formerly an important quarrying place. The stone there has been worked to a depth of 80 feet and forms one great ledge, parts of which are quite pebbly. In recent years this has been utilized in the manufacture of sand-lime brick, but the plant was a financial failure. This locality has an unlimited supply of stone well adapted to bridge and foundation work.

Among the buildings constructed of Hocking Valley stone are the Court House and City Hall at Lancaster. The Court House was erected in 1871 and the walls are as good as when first laid. The color is light brown, with numerous streaks, strips and patches, and the general effect is good. This stone was gotten from the old See quarry in East Lancaster. The City Hall which is trimmed with Bedford limestone may be taken in its general exterior effect as a model for structures of this class in Ohio. The sandstone which comprises the body of the walls was gotten on a farm adjoining the southern edge of the city. Another structure deserving mention is St. Joseph's Cathedral on East Broad Street, Columbus. The basement story was from a quarry near Hanover, Licking County, and the superstructure came from the Sharp & Crook quarry between Lancaster and Sugar Grove.

On the western bluff of the Hocking River, about one and one-half miles above Rock Bridge, is an old quarry where a buff and red-brown sandstone were both worked. The color of the latter, however, was uneven, and in some places not fixed, so that rains colored the walls below. The front of the First Congregational Church on East Broad Street, Columbus, came from this quarry.

Near the State Reformatory at Mansfield is a sandstone ridge which has been the basis of quarrying for perhaps 75 years. About 50 feet of rock are exposed in the old pits and the stone is coarse and rather poorly cemented. The beds vary in thickness from a few inches to four feet and vertical cracks and joints are numerous. The color is usually buff or yellow but occasionally a bed of red occurs. In places the colors are mottled and elsewhere variegated. The latter has shades of red and the cross bedding is very marked. This variety is best known and has been much sought for trimming buildings. Unfortunately it is very soft and friable, but it hardens somewhat on exposure. The ordinary type of the Mansfield stone has had a good market for foundations and bridge work. In 1912 the quarry was worked in a half hearted way, but the operator expected to abandon the place at the close of that season.

THE PENNSYLVANIAN SANDSTONES

The Pennsylvanian or Coal Measure rocks, which form the higher part of the great Carboniferous system, constitute the surface of the eastern third of Ohio, and are subdivided as follows:

Dunkard formation or Upper Barren Coal Measures.
Monongahela formation or Upper Productive Coal Measures.

A.—Court House at Lancaster, built of Hocking Valley sandstone.
Courtesy of Eber Hyde.

B.—Quarry in Mahoning sandstone at Corning, Perry County. The rock is used for bridges, foundations and viaducts. Photograph by D. D. Condit.

Conemaugh formation or Lower Barren Coal Measures.
Allegheny formation or Lower Productive Coal Measures.
Pottsville formation or Conglomerate Group.

The Pennsylvanian formations contain a vast quantity of sandstones, mostly of coarse grain, which are well adapted for structural purposes, and especially for foundations, abutments for bridges, etc. Occasionally rocks suitable for walls of buildings are found but these form a subordinate part of the deposits. These sandstones are interbedded with the coal beds and, therefore, quite regular in their relations with each other, but they vary rapidly in thickness and in other properties. They have never been extensively quarried for building stone and work in recent years has been very light owing to the competition of other stone, and particularly cement.

On the following pages no effort is made to discuss the rocks in their stratigraphical sequence. In fact little more is attempted than to point out the localities where sandstone has been quarried for building purposes, to state briefly the salient features of the rock, to give some idea of the use to which it has been put and the quantity available.

Holmes County has been the one important source of brown sandstone in Ohio. It was found in place as pockets and as loose blocks in the hills east and south of Millersburg and on the hills just west of Killbuck. In the latter quarry a ledge of 35 feet was worked but not more than one-third had the brown color. The color varied from uniform dark brown through various shades of lighter brown and striped to buff or gray. The grain was coarse and cross-bedding was prominent. The stone from this and other quarries was shipped in large blocks and sawed to desired sizes where used. The best of this brown stone had a wide market which extended east to Buffalo, south to Birmingham and west to St. Louis. It may be seen in many residences and business blocks in Ohio. Good examples are shown in Columbus in the Commerce Building, Board of Trade, Young Men's Christian Association and Southern Hotel. Little or no quarrying of brown stone has been done in Holmes County since 1900.

Brown sandstone has been quarried on a small scale in an irregular way along the Mohican and Walholding rivers, and especially near the station Cavallo, where a ledge of 20 feet was worked, the lower 10 of which varied in color from light to dark brown. The stone is coarse and soft and appears to darken rapidly on exposure. The quantity, however, is small and can be secured only by removing the overlying stone. From what has been said it is clear that brown sandstone occurs only in pockets, that the quantity is small and the color uncertain. No deposit of this stone is known in Ohio that can be worked with profit.

Holmes County contains much light colored sandstone that is suitable for building purposes. This is well exposed along Killbuck

Creek and its tributaries and has been worked at numerous places. The stone is massive, coarse-grained and usually of buff or gray color. It was used in building the Court House at Millersburg in 1885, and while the stone has shown durability bad colors developed and the walls have been painted.

Massillon, in western Stark County, has been a quarrying center for half a century. A ledge of sandstone 60 feet thick lying above the Massillon coal was the basis of operations. The stone is shelly at the top, but in layers usually one foot or more in thickness below, and occasionally beds measuring 10 feet may be found without a horizontal break. The color is usually buff but in one quarry a light brown, called pink by the quarrymen, was found. The stone is coarse-grained and porous and, therefore, catches dirt rapidly, its one great drawback. It forms the walls of St. Marys Catholic Church, the Episcopal Church, the First Methodist Church, as well as several fine residences at Massillon, and structures in Canton and other cities. In recent years quarrying for building stone has almost entirely ceased.

Lisbon, Columbiana County, has been the site of considerable quarrying, especially along the valley walls of the East Fork of Little Beaver Creek. In Force's quarry a ledge of 30 feet of coarse gray or buff sandstone was formerly worked. The rock is uneven bedded and somewhat broken. It is well adapted for bridge and foundation work. In the quarry on the Burnett Farm on the bluff of the creek a sandstone ledge of 60 feet has been worked and it is capable of yielding almost any quantity of stone. The Court House at Lisbon, erected more than 40 years ago, came from this quarry. Just across the valley is a smaller quarry, but this like the others, is quiet. These three quarries are all in the same ledge, but in the Force quarry the stone is thinner, the place of the lower part of the stone being occupied by shales. A short distance below the sandstone where it is thickest is a seam of coal, which is known locally as No. 3. It is now mined for local use only, but was formerly shipped.

Sandstone has been quarried at two or more places in the vicinity of Youngstown. At Glenwood Avenue and Freemont Street a ledge of about 30 feet was formerly worked and quarrying did not cease until the rock wall was extended to the avenue. Near the top the stone is shelly and below it is massive. The rock is coarse-grained and has a buff or gray color. Doubtless it was used for bridge and foundation purposes. The Tod quarry is in the northern part of the city and was still in operation in 1913. Below four feet of drift lies 10 feet of thin-bedded sandstone, and below this 40 feet of massive rock. The stone is the usual coarse-grained rock and has a gray or buff color, the latter with numerous brown iron stains

Jefferson County contains much sandstone in the Conemaugh

formation suitable for foundations, bridge work and walls of buildings where a coarse sandstone is acceptable. About one mile north of Steubenville the rock has been worked along the river hills. Thirty-five feet of stone have been quarried and probably the thickness would increase if work extended back farther into the hill. While the rock is coarse-grained it is not as much so as is usually the case in the Pennsylvanian. The rock is without well marked horizontal breaks and the vertical cracks are far enough apart to permit of blocks of any size being quarried. It contains some white mica, which on weathering leaves a powdery substance that whitens the hands. The color of the stone where unweathered is blue-gray, elsewhere it is gray, buff or light brown, depending on the degree of weathering. This ledge underlies a large part of the county and affords an inexhaustible supply. A prominent ledge of sandstone outcrops in the valley of Short Creek in the southern part of the county, and has been worked in a small way.

Carroll County contains a large supply of stone in the Conemaugh formation and, moreover, has one quarry of some importance. This is located on top of a hill about two miles northeast of Sherrodsville, and is operated by the Craig Stone Company. A ledge of about 24 feet of coarse grained, massive sandstone with a gray or buff color is worked. The stone shows prominent cross bedding and occasional black coal-like streaks. Much of the stone is split in the quarry for curbing. The company has a mill with two gangs of saws, and the best stone is sawed for sills and caps. When visited in 1914 fifteen men were employed, but the number was formerly two or three times as great. Probably this stone lies at the horizon of the Buffalo sandstone which, as previously stated, is of importance. Stone from this quarry was used in building the addition to the Broad Street Presbyterian Church at Columbus.

Tuscarawas County possesses large sandstone deposits, well adapted for the more common structural purposes. These lie at several horizons but particularly above the No. 6 or Middle Kittanning coal. In the old Wardell quarry along the western edge of Uhrichsville about 30 feet of stone have been worked. This is massive, coarse grained, gray or buff, but the lower third is decidedly concretionary. The same ledge has been worked a few hundred feet farther north. Some quarrying has been done near the county seat, and the same is true in Franklin and Wayne townships, in the northwestern corner of the county. Some brown stone was found in the latter territory and small use of it has been made at New Philadelphia.

Harrison County was an important quarrying center for many years, though little or no work is now being done. The site was along the valley of Stillwater Creek in the southwestern part of the county, and the first work was restricted to loose blocks lying on the hillside.

It was used for foundations, bridge stone and trimmings for buildings. The ledge from which the blocks were derived is reported to lie about 70 feet above the Upper Freeport or No. 7 coal. About 25 years ago a quarry was opened in the hill just west of Tippecanoe and a ledge of 30 feet worked. The company operated a mill in the valley with four gangs of saws and produced dimension stone, curbing (sawed and split), and grindstones. However, the stone proved sensitive to freezing, and after operating perhaps ten years the plant was abandoned. About 1892 the Latto quarry was opened below Tippecanoe, and considerable bridge stone and some building and pulp stones gotten out. The company failed and a new organization took up the work, but after carrying it on approximately three years the place was abandoned. About the year 1900 the Halderman Brothers of Cleveland opened a quarry just east of Tippecanoe, and installed a modern plant with channeling machines and a mill with three gangs of saws. After a few years the plant passed into the hands of the Cleveland Stone Company who operated the quarry until about 1905 when it was abandoned. The stone is massive, coarse-grained, has a buff color and was used for structural purposes, flagging and grindstones. The walls of the main part of the Broad Street Presbyterian Church at Columbus are from this quarry. The recent addition was from Craig's quarry. Condit has found this to be the Buffalo sandstone and gives the following section at the quarry:[1]

	Ft.	In.
Shale, sandy	15	--
Limestone, *Cambridge*, fossiliferous	--	6
Shale	21	--
Sandstone to base of quarry	46	--

Belmont is another county that contains extensive deposits of sandstone of the usual Pennsylvanian type. Just north of Martins Ferry rock lying below the Pittsburg coal has been worked in a small way in the Ohio Valley hills. Along McMahon Creek is a bed of sandstone that has seen considerable service, but the principal quarry was near McLainville where the rock was described as follows by Condit:[2]

"The sandstone lies about 25 feet below the Pittsburg coal, and has a thickness of over 15 feet. It is a gray, micaceous rock, containing much kaolinized feldspar, which together with a slight amount of secondary quartz as the cementing material, form a fairly firm bond, but one not sufficient to prevent the breaking of angular corners when pressed between the fingers. Silvery mica flakes are abundant, which being unequally distributed, form zones, along which the rock breaks, thus constituting a weakness. Minerals other than quartz, mica, feldspars and their decomposition

[1]Geol. Surv. of Ohio, Fourth Ser. Bull. 17, p. 246.

[2]Idem, p. 245.

A.—Broad Street Presbyterian Church, Columbus. Built of Conemaugh sandstone from Tippecanoe, Harrison County and Sherrodsville, Carroll County. The brown sandstone trimming is from Holmes County, Ohio, and the south shore of Lake Superior. Photograph by T. M. Hills.

B.—View of old sandstone quarry at Tippecanoe, Harrison County. Photograph by D. D. Condit.

products, are few, and in small quantities, as shown when the rock is viewed in thin sections under the microscope. It is especially noteworthy that iron-bearing minerals are in small amounts; hence, the rock should remain comparatively free from rusty-brown stains on weathering. The gray color of the freshly quarried stone has changed to a dark gray where seen in buildings that have stood for several years, but yellowish tints are practically wanting."

The vicinity of Bellaire has long been a source of stone for structural purposes. In the old Robinson quarry a ledge of 40 feet was worked, the upper 17 feet being "very uniform in texture and general appearance," but the rock below was unsuitable for building purposes. "The arches and abutments of the Baltimore & Ohio Railroad bridge across the Ohio River at Bellaire, and a number of other bridges on the same railroad, are constructed of this stone. The old Siebrecht quarry near Martins Ferry supplied the stone for the Suspension Bridge over the Ohio River at Wheeling."[1]

Guernsey County contains workable beds of sandstone in both Allegheny and Monongahela formations, though the supply of good stone does not appear to be large. Stone used in the basement of the Court House was obtained from the Barr Farm, about two miles north of Cambridge, and is still in good condition after a third of a century's exposure. The body of the walls in this structure came from the John M. Hunter Farm near Cumberland, in the southern part of the county. The stone is of medium grain, buff or blue-gray color, and has considerable white mica. It splits into thin layers near the top but is massive below. The rock lies from 10 to 15 feet below the Meigs Creek or No. 9 coal. Being porous the rock catches much dirt and, therefore, darkens on exposure. As shown in the Cambridge Court House, it has good lasting qualities, and is in no wise objectionable. This structure is trimmed with a finer grained and lighter colored stone from the Townsend quarry at Zanesville.

Acceptable sandstone for structural purposes exists also in the northern part of the county, and especially in Wheeling and Liberty townships.

Muskingum County has extensive masses of sandstone suitable for building stone as well as for foundations and bridge work. Probably the best known quarry is the Townsend on Mill Run, which was opened in 1867 and abandoned in 1899. A ledge of about 30 feet was worked and was covered with nearly the same thickness of mantle rock and shale. The sandstone has a fine grain for Pennsylvanian rocks but is a little coarser than Berea. Exposed surfaces have a gray color and show grains stained brown with iron. The beds are very uneven and vertical breaks are common. This rock has stood the test for many years and it is a building stone of merit. For a long time it was the

[1]Geol. Surv. of Ohio, Vol. V, p. 605.

main reliance of Zanesville for sills, caps and water tables, and it forms the walls of Memorial Hall. In recent years the stone has been crowded from the market by the Bedford limestone of Indiana. The base of the quarry is on a level with Mill Run, and hence is below the Lower Kittanning or No. 5 coal.

Ledges of sandstone were quarried along the Muskingum River above Zanesville and used in the Fifth and Monroe street bridges. The stone is much coarser than that just described and doubtless lies at a different horizon. The Muskingum Valley below Zanesville also contains coarse, massive sandstones that have been quarried at several places, and especially between Stone and Cedar Run. The rock lies well up on the hillside and is similar to other sandstones of the Pennsylvanian. It is well adapted for bridge purposes and lies in the Conemaugh formation. Between Cedar Run and Marietta heavy ledges of sandstone outcrop along the valley walls of the Muskingum. While these were not examined they are, in all probability, suitable for foundations and bridge work.

Washington County contains ledges of sandstone that have had local use as long as the county has been inhabited. Piers for the bridge over the Ohio River at Marietta are of sandstone from the A. B. Little farm, about one mile from Newport, and constitute the most conspicuous use of a local sandstone. West of the Muskingum River sandstones have long been quarried for coarse grindstones and the industry is growing.

For 30 years the Mahoning sandstone, which lies above the Upper Freeport or No. 7 coal, was quarried along the Kanawha & Michigan Railroad just below Corning, Perry County. A section of the rock follows:

Mahoning sandstone.	Ft.
Mantle rock and broken sandstone	5
Massive sandstone, buff color	14
Shales, dark color	6
Massive sandstone. Lower six feet blue, the upper part buff	24
Shales, unseen. Dark color	10
Upper Freeport or No. 7 coal.	

The 24-foot ledge is superior to the 14-foot, and alone has been quarried in recent years. The rock varies from blue-gray to buff in color, is coarse-grained, massive, and the vertical breaks permit blocks of any size. Flakes of white mica are common, and on decomposition form a light colored powder that whitens the hands. Coal-like films are occasionally present and of course mar the rock. This sandstone has enjoyed a large market for bridge purposes by the Toledo & Ohio Central and Kanawha & Michigan railroads. It has also had a good

call for viaducts at Columbus, and has been sawed for sills and caps. While this stone is easily obtained, and the supply is inexhaustible, the market has fallen off, and in August, 1914, the quarry was abandoned.

The Pomeroy sandstone overlies the Pomeroy or No. 8a coal, and along the Ohio River in Meigs and Gallia counties has been quarried for structural purposes at several places. The Episcopal Church at Pomeroy was built of this sandstone nearly half a century ago, and the walls are still in first-class preservation. The Catholic Church also has walls of this stone, but the rock in places shows a disposition to crumble, owing to the leaching out of cement. The sandstone has had a large use in erecting buildings for the Epileptic Hospital at Gallipolis. The stone was quarried in the adjacent hills but has not proven first-class. The cement which holds the grains together leaches out on exposure and the rock crumbles. The Pomeroy sandstone is coarse-grained and porous, and hence darkens rapidly. Its color is blue-gray, but on exposure this changes to gray or buff.

INDEX[1]

[1]Prepared by Miss Gertrude S. Kellicott.

Date Due

JUL 15 1968			
CANCELLED			
MAY 15 1974			
APR 11 1977			
NOV 05 1981			
OCT 24 1982			
JAN 18 1983 CANCELLED			